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A BIOMEDICAL ASSESSMENT OF A ONE-ATMOSPHERE DIVING SYSTEM: JIM---ETC(U)

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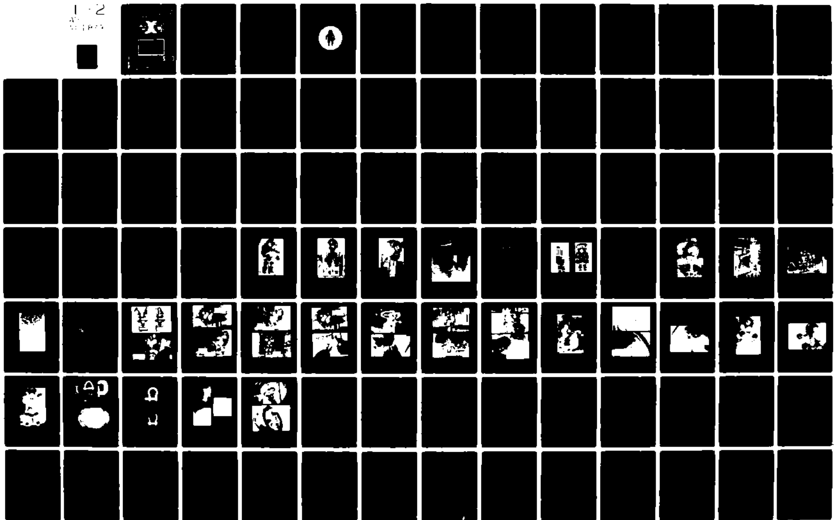

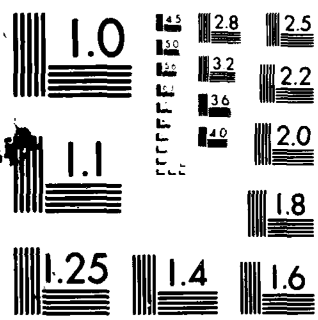

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A BIOMEDICAL ASSESSMENT OF A ONE-ATMOSPHERE DIVING SYSTEM: JIM-4

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Results of the biomedical assessment of a one-atmosphere diving system, JIM-4, conducted by personnel at the Naval Medical Research Institute, are presented in this final report. The report contains an historical perspective of one-atmosphere diving and a detailed research protocol that formed the basis of the assessment, which dealt in particular with human engineering and performance physiological assessments. Results of all experiments are summarized. Three appendices present illustrations of historical developments

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in one-atmosphere systems, detailed procedures for the JIM-4 system as required by the Navy Certification Board, and forms used in the studies and maintenance of the system during the assessment.

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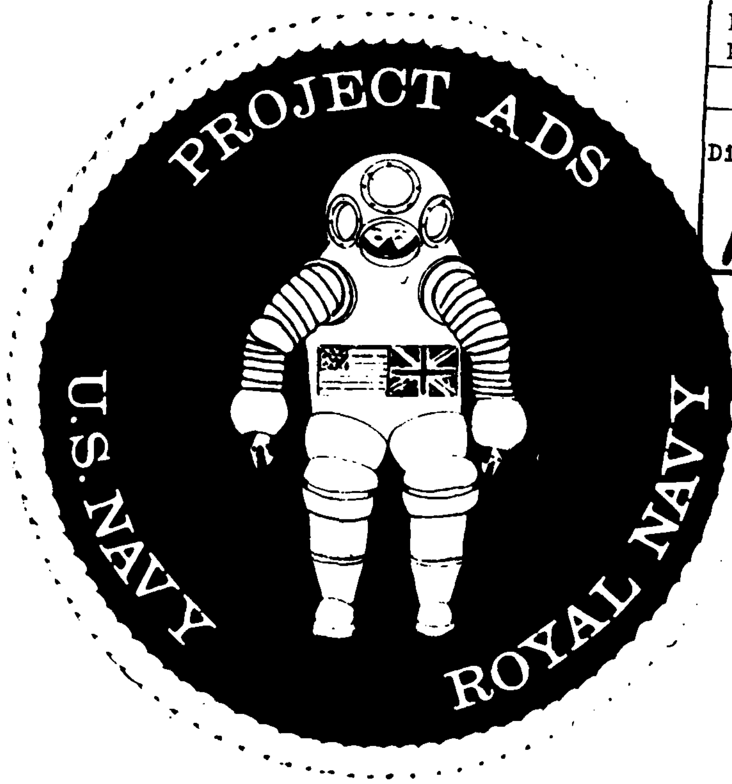

Naval Medical Research and Development Command, Work Unit No. M00099PN.003.3030. The opinions and assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

This report is gratefully dedicated
to the memory of the late Chet Langworthy,
prized friend and colleague.

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Acknowledgments

The present report is a review of a biomedical assessment of the atmospheric diving system (ADS) JIM-4 conducted by personnel from the Naval Medical Research Institute (NMRI).

The JIM-4 assessment was, in all respects, a cooperative one. It was undertaken as part of the Memorandum of Understanding regarding hyperbaric and diving research that existed between the U.S. Navy and the Royal Navy. The specific laboratories identified were NMRI and the Admiralty Marine Technology Establishment, Physiological Laboratory, Alverstoke, Gosport, England. Personnel at DHB Construction, Ltd., (DHB Ltd), Alton, England, were in constant contact with research and operational personnel of NMRI, and DHB technicians were sent to NMRI (and other facilities where research was conducted) to provide assistance and maintenance on a regular basis. Personnel from NMRI were trained in routine maintenance, but the DHB technicians provided regular system maintenance. The principal research and operational personnel who worked on the project are listed on page 13 of this report.

Cooperation between NMRI and other U.S. Navy facilities was essential in executing various portions of the research protocol. These facilities provided opportunities for testing and evaluation that critically supplemented NMRI laboratories. Principal among these Navy facilities were the Circulating Water Channel at the Naval Ship Research and Development Command, Carderock, Maryland; the Undersea Weapons Tank at the Naval Surface Weapons Center, White Oak, Maryland; the Navy Explosive Ordnance Disposal School, Indian Head, Maryland; and the Navy Experimental Diving Unit, Panama City, Florida. These facilities were crucial in the development and completion of the research program, and their excellent cooperation is warmly appreciated. Additional support was provided by the Naval Civil Engineering Laboratory, Port Hueneme, California, which made the DSRV Power Connector available for testing with JIM. The Naval Facilities Engineering Command aided in a similar way by providing an underwater voltmeter. The Naval Air Station, Patuxent River, Maryland, was very helpful in providing an ejection seat and pilot dummy for the studies on underwater rescue. Instructors were provided by the Naval School of Diving and Salvage. The Navy's Harbor Clearance Unit 1, Pearl Harbor, assisted in an offshore diving study as did the University of New Hampshire, under NOAA sponsorship. Dr. James Miller, of NOAA, was most helpful in assisting the study. The Naval Ocean Science Center, San Diego, also provided assistance: Mr. Howard Talkington advised on task selection and Mr. W. Mazzone provided some aid. To all the individuals, Commanding Officers, and staff members of these facilities, we offer our deep thanks.

NMRI is also grateful to the Naval Medical Research and Development Command for support of the program and to Mr. John Freund of the Naval Sea Systems Command who arranged for additional support and offered guidance in developing sections of the research protocol better to address fleet needs.

The cooperation of Oceaneering International, Inc., DHB Construction, Ltd., and the Royal Navy, in particular Tony Gisborne, is noted with deep appreciation.

In preparing the various reports resulting from the JIM-4 assessment, the invaluable aid of Ms. Mary Margaret Matzen, Ms. Regina Hunt, and Mr. Ray Wilder, all of NMRI, is acknowledged with gratitude.

It is not hyperbole to say that the research could not have been done without the active cooperation of the divers and of the asssociate investigators, Michael Curley and John Naquin, and I am most grateful to them.

HISTORICAL PERSPECTIVE

Physiological Constraints

Diving to great depths has been a significant goal for many purposes, principally military advantage, salvage and rescue, exploration, work, and the exploitation of natural resources. There have been, in essence, two main approaches to deep diving: one requiring the physiological adaptation of the human diver to conditions of increased cold and pressure; the other requiring the development of an engineering approach to the environmental conditions so that the human is protected from such changes in temperature and ambient pressure.

Both approaches have advantages and disadvantages. Physiological adaptation can be accomplished to a remarkable degree even at great depths as demonstrated at Duke University in the *Atlantis* dives, in which divers were taken to depths equivalent to 2,250 feet of sea water (fsw) in a hyperbaric chamber. Two factors need to be kept in mind regarding such deep chamber dives: first, there are no data regarding long-term effects of such exposures; second, these dives were in a chamber and not in the open sea, where environmental conditions would have made such control impossible. Indeed, the handling of equipment in the open sea at such depths would pose an almost insuperable problem. Nonetheless, physiological adaptation can be achieved to a significant degree under specific conditions.

The problems attendant upon physiological adaptation to deep diving include those of cold exposure and increased pressure, as stated previously; the adverse effects of the high pressure nervous syndrome; and the problems of decompression. In addition, work methods are dependent upon protective gear such as gloves to ward off the cold and to allow the use of hands. Under ambient pressure, in which physiological adaptation is required, work methods are based on support vehicles, which can provide recompression chambers for divers after deep diving, and on other support, such as gas banks of helium and oxygen and life support systems. Adaptation to pressure is required, whether the method is that of an undersea habitat, in which divers live and work under pressure in a saturated mode, or a Cachalot, in which divers live under pressure in a deck chamber from which they are transferred by personnel transfer capsule to working depth and then restored to the deck decompression chamber after completing the dive. These methods apply to saturation diving. Physiological adaptation is also required for bounce dives or nonsaturation dives, but is less severe in most respects. Problems of decompression and hypothermia persist.

These problems of decompression, hypothermia, and high pressure nervous syndrome are eliminated with atmospheric diving systems. Because operators are not exposed to ambient pressure, they are not compressed or decompressed, and the lack of exposure to ambient temperatures at depth eliminates the problem of hypothermia. The costs of compression in terms of the high pressure nervous syndrome, as an example, are a source of research and operational concern as are the costs of decompression. Not only is decompression costly in the sense of physiological risk, but it is costly in terms of man time. It is

patent that the use of an ADS (atmospheric diving system) in place of an ambient diver, such as a saturation diver, is not always to be preferred. But, if time is a consideration (as might be the situation in an accident investigation at depth), eliminating the compression and decompression through the use of an atmospheric diving system has much to recommend it.

To illustrate this time difference, let us compare lowering a JIM-ADS to 1,000 fsw to a saturation dive to the same depth. In Table 1 the time needed to lower JIM to 1,000 fsw is from 5 to 10 min, compared with the compression schedule for an ambient diver in a saturation mode, which requires staged compression and consumes a total of 17 h 36 min. In a similar fashion, the ascent for JIM would be less than 10 min. As demonstrated in free ascents accomplished on Project ADS (see Summary of Results), an operator in JIM, jettisoning both front and back weights, can ascend at rates approaching 200 ft/min. The required decompression for a saturated diver at 1,000 fsw (Table 2) is 9 days 10 h 40 min.

The JIM-ADS has been the most successful of the available atmospheric diving systems and has had a history of deep working dives since 1972. For this reason, when the Navy indicated an interest in evaluating an atmospheric diving system, it was a JIM system that was selected for the assessment. Table 3 details the diving history of JIM systems from early models to the Type-IV JIM. (Figure 1 shows an early model, JIM-3; Fig. 2 shows the model we assessed, JIM-4; Fig. 3 shows the model currently in use, Type IV. All cited figures are shown in Appendix A.) Table 3 provides a history of working dives, the majority of which were done on contract with oil companies and contractors. This table is slightly modified from a history generously supplied by John Balch of DHB Construction, Ltd., and Bruce Bovie of Oceaneering International, Inc., the firms from which the JIM systems were leased by the Naval Sea Systems Command. There are currently 15 JIM-ADS systems in operation in various parts of the world.

The work methods are limited in the JIM type of ADS, as they are with an ambient diver, by conditions of visibility, and are much more limited in terms of maneuverability when compared to the scuba or tethered surface-supplied diver. The tactile sensivity of the JIM operator is perhaps more limited than that of the ambient diver because the ADS work is accomplished by manipulators operated from within the system, a disadvantage compensated for in some measure by the absence of cold affecting performance with the hands. Diving bells and other types of submersibles have different maneuverability and handling characteristics from the JIM type of ADS, as well as different aspects of visibility, life support, cost of operation, and performance of manipulators.

Our assessment dealt solely with JIM-4, an atmospheric diving system, which, in effect, is a "walking submersible." (The U.S. Navy classifies JIM as a Manned Noncombatant Submersible.) Therefore this section will present, in brief compass, a history of atmospheric diving, which led to the current successful application of engineering and technology to an operational ADS.

TABLE 1

Comparison of Compression Times to 1,000 fsw
of JIM and Divers in Saturation Mode

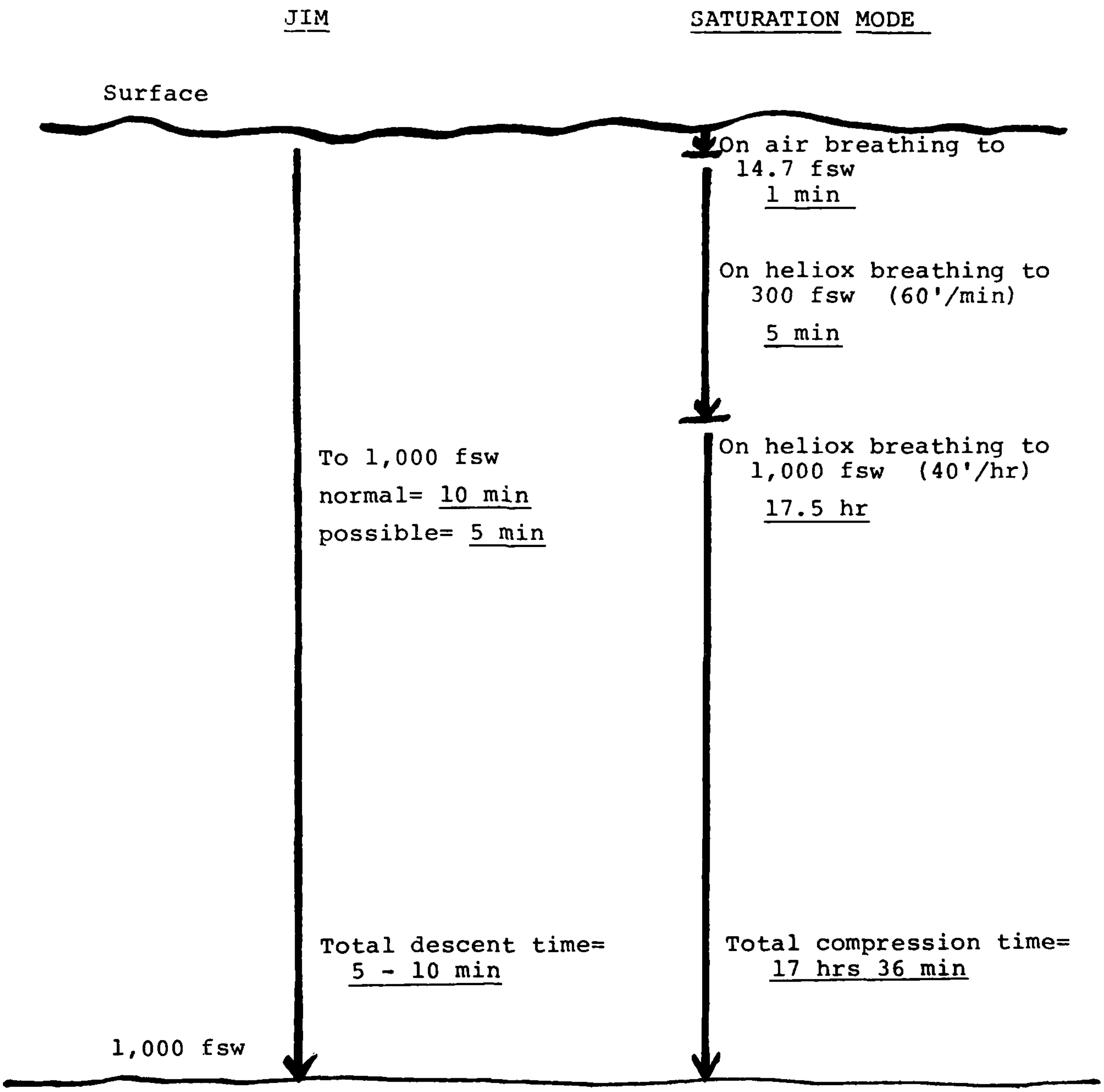

TABLE 2

Standard Navy Decompression Schedule for 1000 FSW Saturation Dive with initial decompression to maximum upward excursion depth limit at a rate of 60 (FPM) and assuming leaving the bottom at 0600. [FPM(feet/minute) - FPH(feet/hour)]

TIME	LV ARR	DEPTH	RATE
0600	LV	1000'	60FPM
0603	LV	820	6FPH
1403	ARR	772	Stop
1600	LV	772	6FPH
2400	ARR	724	Stop
0600	LV	724	6FPH
1400	ARR	676	Stop
1600	LV	676	6FPH
2400	ARR	628	Stop
0600	LV	628	6FPH
1400	ARR	580	Stop
1600	LV	580	6FPH
2400	ARR	532	Stop
0600	LV	532	6FPH
1400	ARR	484	Stop
1600	LV	484	6FPH
2400	ARR	436	Stop
0600	LV	436	6FPH
1400	ARR	388	Stop
1600	LV	388	6FPH
2400	ARR	340	Stop
0600	LV	340	6FPH
1400	ARR	292	Stop
1600	LV	292	6FPH
2400	ARR	244	Stop
0600	LV	244	6FPH
1320	LV	200	5FPH
1400	ARR	197	Stop
1600	LV	197	5FPH
2400	ARR	157	Stop
0600	LV	157	5FPH
1400	ARR	117	Stop
1600	LV	117	5FPH
1924	LV	100	4FPH
2400	ARR	82	Stop
0600	LV	82	4FPH
1400	ARR	50	Stop
1600	LV	50	3FPH
2400	ARR	26	Stop
0600	LV	26	3FPH
1400	ARR	2	Stop
1600	LV	2	3FPH
1640	SURFACE		

TOTAL TIME = 9 Days 10 Hours 40 Minutes

TABLE 3

JIM Diving History 1972-1981

Date	Water Depth(ft)	Location	Summary
Jan '72	440	Scotland (HMS Reclaim)	16 Test dives; bottom maneuver
July '74	300-450	North Sea	Location and inspection of well-heads prior to recovery.
Sept '74	350-400	Off Tenerife Canary Islands	Location and recovery of anchor chains.
Aug '75 Sept '75	300-375	Off Tenerife Canary Islands	Bottom search of area approximately 160,000 sq ft accomplished in 18 dives.
Jan '76	350-384	Beryl Field North Sea	26 Dives. Bottom time total 88 h; inspection of tower base with jigs and fixtures. Force 6 wind conditions.
Mar '76	500-1500 (chamber)	Admiralty Under-water Weapons Establishment Portland, U.K.	Nut task; rope tying; clamp task; hydraulic disconnect; turning top handle. ascend 3/4 h; descend at stop.
Apr '76	905	Canadian Arctic	4 dives thru Moon Pool on ice platform to carry out bottom inspection and make Otis kill line and 3/4" hydraulic hose connections (total 10 h 44 min) Record working dive >500 ft, 5 h 59 min.
Sept '76	600-1100	Rothes Mine Shaft Scotland	12 dives to clear debris from U.E.G. Mine shaft test facility.
Sept '76	1251	Rothes Mine Shaft Scotland	Dive of 6 h 50 min duration clearing pipe and debris in mine shaft.
Dec 11/76	1440	Discoverer D511 Drillship offshore Spain	Four observation dives to 1400 ft plus. Deepest dive 1440 ft to inspect and assist recovery of T.V. cable.
Dec '76 Present	120-1130	"Regional Endeavor" N/W Shelf Australia	General diving support. Jobs completed include inspection, pinger recovery, jetting, clearing debris, AX ring change and guide wire stabbing. More than 150 dives.
Jan '77 Feb '77	394	Forties Bravo North Sea	11 Dives to carry out detailed riser inspection from surface to sea bed.

TABLE 3 (cont'd.)

Date	Water Depth(ft)	Location	Summary
Feb '77	520-540	North Sea	Locate/observe, mark and underwater video sunken supply vessel. Dive to 530 ft brought to surface severed cable; successful free ascent made.
Mar '77	600-800	Aleutian Key Alaska	Drilling rig support. 14 dives to recover drill string and base plate.
Apr '77	300-325	Off Plymouth U.K.	5 Dives to locate Helicopter, secure and successfully recover.
Sept '77	400	Claymore Alpha Platform North Sea	4 working divers from bottom to surface to inspect riser
May '78 Oct '78	1200	Sedco 703 Atlantic off Ireland	22 dives made drilling support.
June '78 Aug '78	700	Taineron Off Brazil	Drilling rig support.
July '78 Present	400	Penrod 72 installer off Brazil	20 + dives made, rig support. Plem installation
Aug '78 Sept '78	400	Smit Lloyd 52 North Sea Norway	10 dives inspection, debris clearance. Gas sampling.
Aug '78 Present	1200	Scarabeo IV Mediterranean Off Italy	Rig support JIM/WASP team. Checked gas leaks; cleaned bullseye.
Jan '79 Aug '79	1200	Southern Cross W Australia	2 JIMS - Rig support.
Feb '79	430	Sedco 471 North Sea	WASP/JIM: Locate wellhead; attach 3/4-in lift cable to 5-in drill string; attach explosives; final inspection.
Aug '79	385	Mediterranean off Spain	WASP/JIM: Evaluation of ADS capability working on production tree. Carried out tasks required for workover; i.e.: corrosion cap removal, guidewire installation, valve cap removal, valve operations.
Nov '79	420	Wodeco 5 off Ghana	2 JIMS: Emergency mobilization to assist in recovery of dropped diving bell; two dives completed less than 24 h after call-out from U.K.

TABLE 3 (cont'd.)

Date	Water Depth(ft)	Location	Summary
Nov '79 Jan '80	420	Wodeco 5 off Ghana	WASP/JIM combination: Second emergency call-out; this time to retrieve BOP stack. Twelve dives made -- stack/riser/drillstring all successfully recovered.
Jan '80	1200	Notroll North Sea	2 JIMS: Rig support; numerous dives made. Tasks included cut/establish guidewires, recover bulls eye, recover 20-in casing, video surveys, clear fouled wires. Operator in JIM did video surveys at depth which has also been done in other dives.
Feb '80	1100	Byford Dolphin North Sea	WASP/JIM: General rig support.
Mar '80 Ongoing	1800	Sedco 704 North Sea	WASP/JIM: General rig support; cut/clear/establish guidewires; remove/replace top Ax ring.
Mar '80 June '80	1100	Borgny Dolphin/ West Venture North Sea	WASP/JIM: Rig support. Numerous dives made; corrosion cap removed; guide-wires replaced.
Apr '80 June '80	500	Scarabeo IV Egypt	2 JIMS: Rig support; retrieved Ax ring, clean bullseye, collected samples, removed jammed explosive from hole.
May '80 Ongoing	1200	Aleutian Key Gulf of Mexico	WASP/JIM: Rig support. Cut and establish guidewires; place explosives. Over 20 dives made to date. 6 dives made to world record depth 1780.
Jul '80 Sept '80	1200	W. Pacesetter II Eire	2 JIMS: Rig support.
Jul '80 Oct '80	1100	Neddrill 2 Canada	WASP/JIM combination: Pinger, recovery, check bullseye, corrosion cap fitting, recover TV, place latching tool for wellhead recovery.
Jul '80	500	Delta Barge Spain	WASP/JIM combination: Workover/re-entry from storage barge. Numerous dives made: guidewires/valves/corrosion cap, still photography survey, overall inspection of well-head, and excursion of 200-ft along flowlines.

TABLE 3 (cont'd.)

Date	Water Depth(ft)	Location	Summary
Feb '81 Mar '81	100	Pinewood Studios U.K.	JIM: Simulated salvage (heroics!) for James Bond film.
Mar '81 May '81	500	Nortroll U.K. North Sea	JIM-JIM: General rig support.
Apr '81 June '81	1200	Sedco 704 North Sea	JIM/WASP: Rig support.
Apr '81 Ongoing	1500	Zapata Concorde Gulf of Mexico	JIM/WASP: General rig support.
Apr '81	1780	Mississippi Canyon Block 28 Gulf of Mexico	JIM/WASP: Team dive made from semi-submersible drilling rig. JIM worked on VX groove and wellhead before BOP was positioned. Record dive to 1780 fsw.

Early Diving Systems

It is generally agreed among diving historians that Lethbridge, in 1715, made the first attempt to create an ADS. Lethbridge, of Newton Abbott, Devonshire, wrote to a London magazine (The Gentleman's Magazine, Sept., 1749) saying that in 1715 he had invented a diving machine made of wainscot that was about 6 ft in length with a diameter of about 2½ ft at the head and around 18 in at the foot [literally a watertight barrel with a glass window and arms that Lethbridge had ordered constructed by a cooper]. No drawings remain of Lethbridge's diving machine, but the one generally referred to is the re-created design of Pesce from his book Navigation Sous-Marine, cited by Davis (1969). This drawing is reproduced as Fig. 4, along with Rowe's diving machine, which was developed about a decade after Lethbridge's and of a similar design. Figure 5 is a recent photograph of the atmospheric diving system WASP, which bears a remarkable resemblance to the machines of Lethbridge and Rowe, in that the diver is encased in a "barrel" with his arms extended through the case so that he can work--albeit (and fortunately) the WASP operator has his arms protected from cold and pressure, unlike the 18th Century predecessors, and he is self-propelled. Lethbridge claimed to have been successful in dives to depths of 10 fathoms and, with "great difficulty," reached 12 fathoms. Rowe's diving machine had marked pressure problems even at depths as shallow as 2 fathoms, according to reports.

Other developments in what came to be known as "armoured diving dress" appeared in the late 18th Century, but the first change in the barrel concept appeared in 1838 when Taylor designed the first articulated armored dress (Fig. 6). It was intended to protect the diver from increased pressure, but the diver's hands and feet were outside the armor, encased in leather. Moreover, the joints were leather and metal rings, like a bellows, and were not likely to be effective under pressure. Unlike the barrel concept, Taylor's design conformed to the human body.

Not conforming to the human body and, as Davis (1969) observed, closely anticipating the first successful modern diving dress (the Neufeldt and Kuhnke dress, shown as Fig. 7), was the design of Philips, published in 1856 (Fig. 8). Davis (1969) states, "The body of the dress is a short, thick cylinder, with domed ends, the lower terminating in a pair of short armoured legs, with ball and socket joints." The hands were encased in metal sleeves and the diver was provided with metal "nippers." The diver entered the dress through the top, through a hatch secured by nuts. This design had two significant advances: first, the encased hands that used manipulators as end-effectors; second, the ball-and-socket joint that was superior to the bellows type of joint designed by Taylor.

Joints, even the ball-and-socket ones, continued to be a problem for almost a century until Peress invented a joint that was much improved. The joints in the armored diving dress tended to freeze under pressure. As late as the 1930's, joints such as those used in the successful

Neufeldt and Kuhnke suits froze at depths around 500 fsw. In addition, external joints often leaked, thereby flooding the suit, a critical problem.

The next significant development in armored diving dress came in 1882 when the Carmagnolle brothers patented an armored diving suit which also used the ball-and-socket joint that Philips had used in preference to the bellows joint. Philips had 10 joints; the Carmagnolles used 22, 6 in each arm, 4 in each leg, and 2 in the body. The joints were to be kept watertight by a strip of linen. Even the improved ball-and-socket joints were subject to problems under pressure. Davis (1969) concluded that a large number of joints tended to increase the possibility of a serious leak in a suit, and that the success of armored diving dress depended upon keeping the joints to a minimum.

Many designs for an armored diving dress appeared in the 1890's (described by Davis, 1969), but the modern era in atmospheric diving systems probably started with the patent of Neufeldt and Kuhnke in 1913. This system carried a major advance--a new type of ball-and-socket joint that allowed for deeper diving--but it still froze at depths approaching 500 fsw. This system (Fig. 7) had a ballast that the diver could use for depth control to a degree. Oxygen was supplied by external cylinders, with CO_2 absorbed by regenerator. In addition to the joint freezing at depth, the 12 joints in the system made it difficult to keep the suit watertight. A later version of the Neufeldt and Kuhnke apparatus was used by an Italian company, the Societa Ricuperi Maritimi (usually known as Sorima), which salvaged some materials from the USS EGYPT, sunk in 400 feet of water off the coast of Brittany. This system had only six joints, one in each shoulder and two in each leg.

Around the time that Neufeldt and Kuhnke were developing their system, an Italian developer Galeazzi produced an atmospheric diving system (Davis, 1969). A photograph in Davis's book shows a 1930's Galeazzi suit that is virtually identical to a recent Galeazzi suit photographed in 1976 (Fig. 9). Also about the time that Neufeldt and Kuhnke were developing their system, an inventor named Joseph Peress was developing an armored diving dress in which the joints were sealed in liquid, an important breakthrough. Earls and Hall (1978) describe this joint as a "fluid-supported joint, the principle of which was based on a spherical piston and cylinder with the fluid acting as a thrust bearing contained by a rolling fabric diaphragm." Earls and Hall (1978) observed that this principle formed the basis for further development. Peress obtained more patents, which provided the design for the joints used in the current JIM series.

In 1933 the British Admiralty ran a successful test of Peress's diving system, TRITONIA (Fig. 10), and on October 26, 1935 Jim Jarratt dove the TRITONIA to a depth of just over 300 fsw to find the wreck of the OSTS LUSITANIA. Jarratt also had dived the system to 500 fsw in Loch Ness. As a side note, Jim Jarratt, Peress's diving technician, was the source of the name JIM for the ADS series. JIM is not an acronym for anything.

Joints invented by Peress proved more efficient at depth than previous designs and the possibility of diving to depths greater than 600 fsw was made a reality, not only because of the improved performance at depth but because the joints, reduced to the minimum Davis had predicted and more effective, were also watertight.

Even with these successes and potentials for greater use of atmospheric diving systems, interest in the one-atmosphere suit declined around the time of the Second World War. We can speculate regarding the reasons for this decline in interest and use.

In all probability, one reason for the decline was the development of the aqualung. Self-contained diving systems have a long history. In 1926 LePrieur and Fernez patented a self-contained diving apparatus and developed an improved version in 1933. In 1930 another Frenchman, de Corlieu, patented swim fins, probably the first time a diver was viewed in the swimming position since Borelli had done so in 1680. With tank and fins, the scuba (self-contained underwater breathing apparatus) became a reality. One major problem was that the LePrieur apparatus was free flow; therefore it wasted air. Gagnan solved this problem by adapting a plastic valve to the aqualung and creating a demand valve so that the free flow was no longer a problem. Gagnan's device, known as the Cousteau-Gagnan aqualung, was successfully tested to a depth of 220 fsw in 1943 by Dumas, who spent 15 min at depth. Thus scuba made supplements to hardhat supply diving feasible.

In addition, changes in hardhat diving were occurring. In 1939 the successful salvage of the USS SQUALUS at 243 fsw by the U.S. Navy demonstrated the usefulness of helium/oxygen mixtures in deep diving. This salvage was the first open-sea use of helium as a breathing mixture; the increase in depth as a result of the new gas mixture enabled diving operations to go to depths in excess of 300 fsw. Inasmuch as most atmospheric diving systems could not operate much below that depth, the need for the armored diving dress was probably considered unimportant.

A resurgence of interest in atmospheric diving systems really appeared in the late 1960's. In all likelihood this resurgence resulted in part from increasing interest in offshore oil exploration. In 1967 a group in the United Kingdom developed concepts of an atmospheric diving system that employed the joints developed in the 1930's by Joseph Peress. In 1969 a corporation, DHB Construction, Ltd., of Alton, England, was formed to re-examine the problems encountered in earlier armored diving suits and to assess the potential use of such systems. Their efforts resulted in development of the JIM diving system, which is a direct inheritor of the design of Peress's successful TRITONIA (Fig. 10). An early JIM, JIM-3, is shown in Fig. 1. An early version of JIM and TRITONIA are shown side-by-side in Fig. 11.

Later developments in the JIM series consisted of a modified concept called SAM, which was conceived to be aluminum and ultimately fiber glass, rather than the magnesium alloy of which JIM was constructed. The SAM arms were articulated in a more flexible fashion, and the JIM-4 Fig. 2), which we assessed, had SAM arms. The contrast in arms is seen

in Figs. 1 and 11. Another significant change may be seen in comparing JIM-3 (Fig. 1) with JIM-4 (Fig. 2). The manipulators in the earlier model were a one-to-one finger control with five "fingers"; the manipulators in JIM-4 and in current models are steel parallel jaw grips. The Type-IV system, currently in use and significantly modified, is shown as Fig. 3.

PROJECT ADS: A BIOMEDICAL ASSESSMENT OF A 1-ATA DIVING SYSTEM

Background

The beginnings of the assessment of JIM-4 had their roots in research ongoing at NMRI that investigated the effects of the high pressure nervous syndrome in deep diving. An atmospheric deep diving system was viewed as a possible alternative, under certain circumstances and conditions, to human exposures to great depths. As noted previously, the two routes to deep diving are to require the human to adapt physiologically to pressure effects and other ambient conditions encountered, or to engineer the environment so that the surface atmosphere is taken to depth, making it unnecessary for the human to adapt physiologically, as is done in diving bells and submersibles. Because JIM had been classified by the U.S. Navy as a Manned Noncombatant Submersible, the system was considered to be an engineering alternative to ambient deep diving; therefore a biomedical assessment was proposed to evaluate the potential of such an atmospheric diving system for Navy use.

The Naval Medical Research Institute proposed this assessment and was funded by the Naval Medical Research and Development Command, with additional support provided later in the study by the Naval Sea Systems Command. The assessment was conducted by research and operational personnel from NMRI with cooperation from other agencies, principally the Royal Navy's Admiralty Marine Technology Establishment Physiological Laboratory. Table 4 provides a complete list of the principal personnel engaged in the research. The system, JIM-4, was leased through the Naval Sea Systems Command from Oceaneering International, Inc., and its affiliate, DHB Construction, Ltd., of Alton, England. JIM-4 was delivered to NMRI in late October 1977 and the research program was begun in January 1978 after a preliminary certification for Navy research use was granted.

To provide completeness and to indicate the operational planning that went into the support of the experimental research program, we have included Appendices B and C. Appendix B details the procedures developed for the Navy Certification Board, NAVSEA Code 924R, regarding each component of the JIM-4 system and its use and maintenance. Appendix C shows samples of the forms that are regularly kept in all operations. Data forms used in the experiments have not been included.

The JIM-4 ADS was the fourth development in the JIM series, having a significant modification in the use of arms developed for another system, SAM, which had articulated arms of greater range and flexibility than the JIM arms used in earlier models. As stated previously, Figs. 1-3 and 11 in Appendix A show early JIM models, JIM-4, and the latest

TABLE 4

Personnel, Project ADS

Principal Investigator	Arthur J. Bachrach, Ph.D.[1]
Associate Investigators	Michael D. Curley, PhD, LT, MSC, USN John C. Naquin Henry C. Langworthy

Research and Operational Personnel

Diving Officers
L. "Chips" Hurley
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Peter McKibbin
P. Anthony Moore
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Consultants
Glen Egstrom, PhD., UCLA
James Joiner, Commercial Div. Ctr.

JIM Operators
HT1(DV) Roger Seeley
BMC(DV) Robert VanDine
MM2(DV) Daniel Fischer
STG1(DV)Carl G. Cross
MR1(DV) C. Mark Weaver
GMG2(DV)Donald Sayre
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Cliff Newell
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For Project LS-10 (Life Sciences) under Memorandum of Understanding US Navy/Royal Navy

Principal Investigator (US)	Arthur J. Bachrach, PhD NMRI
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model, Type IV JIM-ADS. The technical information on JIM , provided in Table 5, applies with one exception to earlier JIM models, including JIM-4: JIM models were rated to 1,500 fsw, but the model with which NMRI worked, JIM-4, was rated to 1,250 fsw. This difference was not a problem inasmuch as the NMRI assessment was a laboratory and tank assessment with a depth limit set at 100 fsw, a depth that met the requirement of the Certification Board for early studies as well as the research protocol.

Technicians from NMRI were trained in routine maintenance of the JIM-4 system by technical personnel from DHB Construction, Ltd., but periodic maintenance was performed by DHB itself, either in the United States or in England. The system was sent back to England for refurbishing and thorough check and maintenance on a regular basis.

Research Protocol

The research Protocol for the assessment of JIM-4 evolved over the period of experimental work, was modified to allow for needs perceived as the research was conducted, and was altered to suit contingencies. The protocol was conceived to be a balance between basic laboratory research (e.g. the psychophysical experiments and the closed-gas-loop analysis) and fleet-relevant studies, which included demonstrations such as the ability of JIM's operators to place a DSRV power connector or to release a downed pilot (dummy) from an ejection seat underwater.

One task area that had to be omitted from the protocol, a comparison of the performance and physiology of a JIM operator with a diver in a Mark XII hardhat system, appears at the end of the protocol under the section Future Plans and Possibilities. This comparison was developed to compare both the efficiency of the JIM and Mark XII systems for performing tasks and the physiological energy costs attendant upon them. Because of procurement delays in supplying the Mark XII, this comparison had to be omitted.

On the surface, such a comparison might appear unnecessary and even specious, inasmuch as the two systems were designed for different operations and for different depth requirements. Investigators at NMRI had previously participated in a similar comparison of the Mark V and the Mark XII (Bachrach, Egstrom, and Blackmun, 1975), but these systems were designed for similar operations. The reason for comparing a deep diving atmospheric system with a hardhat system was that fleet personnel were considering the use of a JIM system for work at relatively shallow depths for long periods of time--use of the JIM system would preclude the need for decompression.

A. Familiarization and Training

The following techniques provide a means of assessing the adequacy of existing familiarization and training procedures for novice operators of JIM.

Inasmuch as the efficient maneuvering and operation of JIM-4 is dependent upon the acquisition of rather unique skills (for example,

TABLE 5

JIM Technical Information

Beam: 3.1 ft.
Height: 6.5 ft.
Weight Dry: 1,100 lb. (including operator)
Weight Submerged: Approx. 60 lb.
Working Depth: 1,250 ft. (JIM-4)
Manipulators: Multipurpose grippers

Life Support: 24 hrs.
Power: Manual
Crew: One Operator
Communications: Hard Wire/Acoustic
Temperatures from body heat and CO_2 scrubbers: Stabilize at 68-85°F

Descriptive Information:

Pressure Hull: Main body and dome, leg spacer and boots are composed of magnesium Alloy RZ5. Joints and elbow spacers are composed of aluminum alloy forgings. Body parts are impregnated with a sealing agent and coated with hot applied, then several applications of cold applied epoxy.

Joints: Joints are O-ring sealed spherical ball type. They are filled with vegetable oil. O-ring failure will cause the joints to sieze up but will not cause loss of suit integrity. External pressure will cause the finished male and female joint components to seat to one another.

Life Support: The operator breathes one atmospheric air. O_2 make up and CO_2 removal is provided. O_2 is carried externally in two 440 liter flasks at 150 atm. The operator wears an oral-nasal mask with inhale and exhale hoses both connected to CO_2 scrubbers (soda sorb) which pass exhaled gas into the suit body and pass inhaled gas from the suit body to the mask. O_2 is metered into the inhale side of the mask as regulated by a demand regular adjusted to maintain suit pressure at one atmosphere. The operator can add O_2 directly to the suit to maintain cabin pressure. There are two completely independent O_2 make-up/CO_2 removal systems each of which can be connected to either O_2 flask.

Monitoring: Operator monitored instruments include O_2 partial pressure, cabin pressure, O_2 flask pressures, O_2 pressure down stream of the pressure reducer and temperature. Operator breathing sounds can be monitored topside.

Communications: Communications may be provided by either a hard wire to the surface or by an acoustic system. A Helle communications box is incorporated. Emergency communications consist of a pinger and a flashing light in the event the suit must free ascend.

Ballast/Buoyancy: Approximately 150 lb of lead ballast is used to obtain 60 lb. negative submerged weight. All weights are jettisonable by the operator creating sufficient buoyancy to attain an ascent rate of approximately 100 feet per minute.

Tether: A light lowering/lifting line is connected to the top of the suit with the communications wire seized to it. The line is used after the system is in the water. A separate lift system is used to lift the system into and out of the water. The tether is jettisonable by the operator in case of entanglement or if a free ascent is required.

exaggerated shifts in body weight for turning, use of manipulators, etc.), the methods of training in the establishment of training objectives are crucial if the most effective and economical use of JIM is to be realized. It was the purpose of this part of the assessment to provide definitive training objectives to analyze the current procedures with regard to these objectives and to make recommendations concerning a future training protocol.

1. Swimsuit baselines: movements

2. Orientation dive: 15 min free time

3. Debriefing/questionnaire

4. Observation of sequence of training

   a. Classroom (C) and practical (P): manual development
      (1) Content
      (2) Format
      (3) Methods of instruction

5. Instruction in diving operations and procedures

   a. Review of emergency procedures

C=Classroom
P=Practical

C (1) Loss of suit integrity, leaks
C (2) Life support malfunction
C/P (3) Entanglement
C (4) Loss of communication
C/P (5) Disorientation/visibility problems
(6) Emergency ascent; weight jettisoning (10 ft at Carderock; 100 ft at Naval Surface Weapons Center)
(7) Standard procedures
   (a) Predive preparation, including time for preparation
   (b) Postdive procedures, including debriefing questionnaire

   b. Assembly and maintenance procedures

C/P (1) Assembly from completely disassembled system
C/P (2) Preparation for diving operation, including lubrication, CO_2 scrubber, communications check, leak check, handling system.
C/P (3) Routine maintenance
C/P (4) Disassembly and storage, postdive.

6. Functions measured

   a. Movement and maneuverability
      Negative buoyancy, individual diver at depths 15/30/100 ft
      (1) Simple movements
         Arms
         (a) Raise arms individually from lowest to highest levels
         (b) Move arms horizontally inward and outward to greatest extent individually
         (c) Move arms together to highest and lowest levels
         (d) Circle arms individually through full range of motion.

Legs
(a) Shift weight and lift legs individually
(b) Slide a leg out to one side and bring together
(c) Shift one leg backwards and bring it back.

(2) Moderate movements
(a) Straight walk and turn around; walk with current and against current
(b) Fall forward and fall backward with recovery from both
(c) Lateral motion (back and forth)
(d) Walk up steps on JIM Gym, maneuver 360° on platform, walk down steps
(e) Roll over from supine position on deck.
(f) Maneuver on circling line, against current

Purposes of Movement Evaluation

1. Familiarization with suit capabilities

2. Allow ranking of training tasks in terms of complexity

3. Presentation of graphic data for each task.

B. Human Engineering and Performance Physiological Assessments

The following outline provided a means for evaluating JIM with respect to two important human factors. Through physiological monitoring it was possible to assess the general physiological status, energy costs, and degree of physical exertion required of the operator during the various phases of training and performance. An examination of the biomechanical aspects of JIM was designed to furnish information concerning static and dynamic nature of the basic suit configuration. Among the tasks learned in still water and repeated in current were to walk, turn around, operate a gate valve, and transfer nuts.

1. Physiological monitoring: Baseline and operation

a. Heart rate

b. Pulmonary: respiration rate
(1) CO_2 production
(2) O_2 consumption

c. Temperature differentials
(1) Suit
(2) Skin
(3) Ambient water temperature

A crucial variable, as noted, is the energy cost required for performance in JIM by the operator. This quantification of physiological variables in both still water and current is important to the overall assessment of operator physiology and performance.

2. Biomechanical Aspects

a. Static strength and functional muscle groups (using UCLA Isokinetic Station)

(1) Upper body
  (a) Grip, skill in T-bar
  (b) Pronation and supination, radio-ulna joint
  (c) Flexor/extensor component
  (d) Shoulder joint and shoulder girdle
(2) Lower body--hip

b. Dynamic strength and functional muscle groups

(1) Drag object
(2) Push/pull
(3) Lifting procedures: hip, shoulder, elbow
(4) Load carrying and handling capabilities
(5) Distance capabilities, energy cost

c. Evaluation of reach envelopes

Load carrying and handling capabilities and distance capabilities provide a quantitative measure of endurance and fatigue. The biomechanical aspects studied provided strength measurements, force production and evaluation of manipulated dexterity, reach envelopes and operator anthropometry, dynamic anthropometry, internal and external reach envelope measurements, and mobility on inclines; all of these measures were quantified for an assessment of range-of-motion, flexibility, agility, and mobility.

3. Performance: Simple and complex

This portion of the evaluation provided a means of assessing the crucial aspect of task performance and its training. Could JIM and a trained operator effectively execute the various operational tasks required of them? What were JIM's manipulative potentials and limitations with respect to the use of standard tools that are characteristic of inspection, salvage, and construction?

The ability to use hand tools in simple and complex tasks is critical for operational effectiveness, as is the ability to use shackles and wire straps with clamps and to attach studs.

a. Simple tasks

(1) Fall forward, pick up a small pipe and recover
(2) Transfer pipe from one hand to the other.

b. Complex tasks

(1) Using a sling, pass one eye through the other, around SP^2 (the NMRI task assembly), and workbench
(2) Turn valve handles: 4-in valve positioned horizontally and vertically; gate valve a) no loading, b) pressure on one side
(3) Place 1-in shackle on a plate
(4) Align piping flanges and bolt them
(5) Handle ADS in open sea and research facility
(6) Gather water samples in open sea (Gulf of Maine, 100 ft)

(7) Read and report reading of underwater voltmeter
(8) Connect shackle on deck in quasi-horizontal position (i.e "hovering")
(9) Plug in and lock DSRV power connector
(10) Transfer 3/8-in nuts from one spindle to another
(11) Shackle lifting straps on underwater JIM Gym
(12) Pick up small, flat objects (e.g. washers) from deck
(13) Release (unbuckle) dummy pilot underwater from ejection seat
(14) Photograph objects underwater from within JIM, through faceplate, using 35-mm still camera and cine camera
(16) Tie bowline
(17) Simulate torpedo recovery with 8-in pipe, padeye, and wire straps with clamps
(18) Operate air hose and activate lift bag.

4. Sensory feedback

The goal was to evaluate the JIM operator's awareness of body parts in relation to one another and the environment, especially localization of external stimuli, and to assess the operator's capabilities to perform in altered environments such as degraded visibility and variations in temperature.

a. Psychophysical judgment
Without visual cues, operator estimated weights of loaded canisters in relation to standard weight as a) equal, b) heavier, c) lighter.

b. Tactile sensitivity
With degraded visibility (up to no visual feedback) operator identified objects such as C-clamps and wrenches solely by touch through manipulators.

c. Visual field evaluation
(1) External assessment of visual limitations of the operator on the system included:
(a) Static. The visual field was mapped using perimetry and the method of limits while the operator held his head and eyes stationary and looked through the individual ports.
(b) Dynamic. The visual field was mapped using perimetry while the operator moved his head and eyes as desired.
(2) Internal evaluation to determine whether life support instrumentation and emergency equipment could be seen without difficulty.
(a) Measurement of the viewing distance to instrumentation.
(b) Accuracy of reported observations.

5. Environmental variation

The following environmental factors affecting operator performance in JIM were assessed:
a. Effects of current upon performance of various tasks (compared with still-water baseline).

b. Effects of temperature variation upon baseline performance. The effects of hyperthermia on performance and physiological cost were assessed at increased ambient temperatures.

c. Degraded visibility (discussed under sensory feedback).

6. Life support study

Physiological data were collected from the ADS (JIM) under laboratory conditions as appropriate and during all related manned operations:

a. Suit atmosphere (cabin) and oral nasal mask were monitored intermittently or continously for a) oxygen, b) carbon dioxide, c) temperature, and d) water vapor.

b. *Breathing resistance (as a function of respiratory flow rate)* of the oral nasal mask, gas supply system, and gas filtration system was obtained at varying work rates.

c. The system's ability to maintain a mean PO_2 and the PO_2 deviation from this mean were assessed at different work rates.

d. Pressure changes were monitored within the cabin.

e. Manual operation of life support system controls and manual gas supply were assessed by human engineering analysis.

f. Weight placement on external suit surface was assessed for optimal mobility and buoyancy control.

Future Plans and Possibilities

If there were an opportunity to renew an assessment of JIM-4, I would recommend that these tasks be accomplished. (I recognize that JIM-4 has been superseded by Type-IV-ADS; however, I consider these tasks are pertinent to an assessment of operator performance and physiology in the system.)

Maneuverability

a. Hatch simulation. Move through an opening, the top of which is lower than shoulder height. Added: angle iron door variable opening.

b. Walk on incline. Cross 8-in incline on JIM Gym, varying 15° to 45°.

c. Traction. Simulate slippery surface (e.g. rubber mat and maneuver surface).

Tool Use

a. Repeat tasks done using standard tools with hydraulic tools, as appropriate

b. Exchange end-effectors under water. Contingent upon availability of interchangeable manipulators.

Tasks

a. Underwater television surveillance

b. Submarine rescue
(1) Hatch clearing for DSRV operations
(2) Salvage air connection
(3) Ventilation air connection
(4) SRC downhaul cable attachment

c. Tug on line against force, pulley

d. Torqueing, with and without restraints (strain gage measurement)

Physiological Measurements

a. Measure water vapor content in both respiratory gas and suit environment at various conditions of work, respiratory rate, and ambient water temperature.

b. Measure surface heat flux with correlated surface temperatures obtained during physiological studies at various conditions of work and ambient water temperature.

c. Measure environmental characteristics of water vapor, internal suit temperature, and external suit and skin temperatures.

Biomechanical and Anthropometry Measures

Biomechanical measures such as range of motion repeated with light-emitting diodes (LED's), already completed, would be placed as landmarks along JIM's structure.

System Comparison

All tasks, performance and physiological, repeated under identical conditions using Mark XII system to compare with JIM.

SUMMARY OF RESULTS

An overview of the results of the various experiments and studies is presented. Full accounts of the scientific data gathered are not included because of space limitations; however, the data have been, and will be, published in appropriate scientific journals and other avenues of publication. A bibliography of reports that have been published appears at the end of this section.

All of the tasks, demonstrations, and experiments were photodocumented in a film (titled "A One-Atmosphere Diving System," see Publications list) and in still photographs. Appendix A presents a number of these, noted at appropriate points in the discussion. In discussing the general findings of the biomedical assessment of JIM-4, I will follow the outline of the research protocol, beginning with the first phase of familiarization with the JIM-4 system and training in its

use and maintenance. In this phase the cooperation of our British colleagues from the Royal Navy and DHB Construction, Ltd., was essential.

A. Familiarization and Training

The orientation dives were begun in January 1978 at the Circulating Water Channel, David Taylor Model Basin, Naval Ship Research and Development Command, Carderock, Maryland. The ensuing orchestration of classroom and practical in-water work resulted in the development of a preliminary training manual. Operation of JIM-4 and maintenance, both pre- and postdive, were covered in detail. The British experience suggested that the time for proficiency in operating the JIM system required around 15 hours of in-water training and experience, a time that was roughly cut in half with the U.S. Navy divers in this project. We conjecture that the principal reason for the shorter time required for U.S. Navy divers to attain operator proficiency is their experience with hardhat systems such as the Mark V. Most Royal Navy divers lack this experience inasmuch as the emphasis in Royal Navy training and diving is on scuba gear such as is used in mine clearance diving. Although it is manifestly a conjecture, we believe that the hardhat experience generalizes to the types of body movements required in operating the JIM system.

Emergency procedures formed a significant part of the training program. The JIM system is self-contained so that the tether and weights may be jettisoned in case of emergency. To test the operator and the system in an emergency ascent, the project moved to the Underwater Weapons Tank, Naval Surface Weapons Center, White Oak, Maryland. The tank is a 100-ft deep, 50-ft radius enclosed tank, and it was possible to lower each diver to the bottom and have him drop his weights, front and back, to ascend. Figure 12 in Appendix A shows a diver in JIM-4 emerging at the tank's surface following an ascent. The operators said they were unable to move the JIM system from the straight ascent path; therefore they were instructed to pitch or roll the system on ascent to determine if they were able to move the system from the straight ascent path, but they were not able to change the straight ascent. Moreover, the operators reported that they were not aware that they were moving until they looked out of JIM's port and saw the numbers marking the heights painted on the tank wall. Jettisoning front weights demonstrated that an operator in JIM could surface in a straight ascent at rates up to 100 ft/min while dropping both front and back weights; this maneuver resulted in ascent times approaching 200 ft/min. The lightest diver/operator exceeded this ascent time by surfacing from 100 ft in 23 sec.

Biomechanical Assessment

Movement and maneuverability in the system were measured under varied conditions. The operators moved arms and legs in various ranges and positions, and a series of anthropometric measures of movements was obtained in which operators in JIM were compared against their baseline grid in a swimsuit. Initial studies involved simple movements such as arm-raising, horizontal extension, and circling through full range of motion. The swimsuit baselines measured 14 basic motions on each operator so that a range of motion could be analyzed. These movements

were drawn from a study accomplished on divers in a biomechanical comparison of the Mark V and Mark XII (Bachrach, Egstrom, and Blackmun, 1975) and were designed to test a range of movements divers could be asked to perform, such as knee flexion and arm-raising. About half of the movements proved impossible to perform in JIM owing to its configuration, but significant flexibility and mobility were possible in the remainder of the movements.

In addition to these basic anthropometric tasks, functional-strength muscle studies were done (using a Cybex) on the first group of JIM operators with the cooperation of the Sports Medicine Department at the U.S. Naval Academy. Studies of static strength and functional muscle groups were also done at NMRI with the cooperation of Dr. Glen Egstrom of the Department of Kinesiology, University of California at Los Angeles. These tasks, listed under the Human Engineering and Performance Physiological Assessments (Biomechanical Aspects) section of the Protocol, proved successful. A JIM Gym was constructed so that multiple tasks including performance assessments could be made. Operators demonstated good capabilities for such movements as pronation and supination and T-bar grip. (The T-bar is illustrated in Fig. 14).

Maneuverability in the system was measured in a variety of ways, including straight and figure-8 walks. In the straight walk series of studies, operators in JIM walked 60 ft, 30 ft back and forth. These walks were accomplished in still water and repeated in current. The use of the Circulating Water Channel at Carderock enabled us to quantify the current in the channel. Operators had no difficulty in completing walks. In the current studies, operators performed 60-ft walks consisting of 30-ft with the current and 30-ft against the current; the main finding was that the walk against the current took significantly longer than the 30-ft walk with the current, not a surprising datum. Also not surprising, the longest timed walk against the current was at 0.75 knots (mean time = 136 sec) and the shortest against 0.25 knots (mean time = 47 sec). The same relationship obtained for the 60-ft walks (30-ft with and 30-ft against current) with the longest at 0.75 knots (mean time = 166 sec) the shortest at 0.25 knots (mean time = 79 sec). Figure 15 shows an operator walking against a 0.75-knot current.

Operators were also studied for maneuverability in falling and recovering from a fall to the deck. The operators were able easily to fall and recover. Figure 16 depicts a diver-operator falling backward and preparing to restore his balance.

Another maneuverability study was accomplished using step tasks. These were done on a specially designed and constructed assembly called the JIM Gym (Fig. 13). Operators walked up the steps, turned a complete 360° on the platform and walked down the JIM Gym. Figures 17-19 show the operator in portions of this ramp walk on the steps. These step tasks were also repeated under conditions of current. Under conditions of created currents of 0.25 knots, there was no statistically significant difference in times between step maneuvers done with the current or against the current. (Mean time with current = 44.5 sec, mean time against current = 41.6 sec). This changed somewhat when the current was increased to 0.50 knots (mean time with current = 57.0 sec,

mean time against current = 73.4 sec). A full analysis of statistical difference could not be made because there were fewer step maneuvers completed at 0.50 knots than at 0.25 knots; however, the trend is clear that the higher current slowed performance. Two operators attempted to accomplish the step maneuver at 0.75 knots but were unable to do so.

Other tests of maneuverability were the ability to roll over in the system on the deck from a supine position (Fig. 20) and to walk hand-over-hand (manipulator-over-manipulator) traversing a circling line. Figure 21 shows the operator traversing a circling line against a current set at 1.00 knot. The manipulators are shown as Fig. 14.

B. Human Engineering and Performance Physiological Assessments

Physiological Monitoring

The physiological cost of operating the JIM system was an important datum to be obtained. In a report to the Undersea Medical Society (Langworthy, Bradley, and Bachrach, 1979) the results of assessments of physiological costs in operating JIM were presented. Each time the task was performed the operator was physiologically monitored; oxygen consumption ($\dot{V}O_2$) and heart rate (HR) were measured at rest and during several steady-state conditions of performance on a bicycle ergometer in the laboratory. During JIM operations, HR was measured under steady-state conditions of performing the standardized tasks as detailed in the Protocol. By taking the physiological measures on the first trial on the task and on succeeding trials, it was possible to evaluate potential changes in task performance correlated with physiological change.

A linear relationship between $\dot{V}O_2$ consumption and HR was reported by Langworthy, Bradley, and Bachrach, 1979. Thus, the HR was used as an approximate index of the $\dot{V}O_2$ during the task performance.

The report further indicates that the first trial in a task required work loads of heavy to very heavy. As an example, walking at a brisk rate in JIM for the first time produced a mean steady-state HR of 148 beats/min (range 132-162), which the authors stated corresponds to an average $\dot{V}O_2$ 2.32 L/min (range 1.85-2.6).

These physiological measures ($\dot{V}O_2$ and HR) were also taken during specific tasks listed in the Protocol, particularly in placing a shackle on a plate (Fig. 22), aligning and bolting flanges, and transferring 3/8-in nuts from one spindle to another. All of these tasks generated increased HR's on first trials. The highest HR's were obtained during the deployment of a lift bag, with an average HR among the divers of 157, a range of 151-164, and the highest $\dot{V}O_2$'s approximately 2.7 L/min. Heart rates decreased from 15% to 20% following the performance of a task several times, which would suggest an extrapolated decrease in $\dot{V}O_2$ of 20% to 30%, a decrease interpreted to represent increased comfort with the suit and efficiency in its use that resulted from learning, training, and adaptation. These results show that the physiological cost of operating in JIM is high, particularly during initial trials, but decreases with experience to some degree. A comparative study of a diver performing in another system, doing the identical tasks, would be

of value, and this type of data is suggested for future research in the final section of the Protocol presented earlier.

Performance: Simple and Complex

In the Protocol there were a number of tasks that the operators in JIM performed, tasks selected to represent the type of work that might be required underwater. The assessment was clearly directed to seeing whether an operator in JIM could successfully perform tasks that involved fine and gross motor coordination. As with other tasks, these performance tasks were accomplished in still water and then repeated, for purposes of comparison, in water in which currents were generated. In the majority of the tasks to be discussed in brief there was no significant difficulty encountered by operators in completing the work in current up to 0.5 knots, above this there was a problem of successful completion. As noted, however, maneuvering a circling line against a 1-knot current was accomplished successfully, virtually the only task completed at that level of current.

The operator was required to turn a gate valve (Fig. 22) and experienced no difficulty in completing that task either in still water or against current. Similarly, placing a shackle (Fig. 23) was accomplished with no significant difficulty, as was the alignment and bolting together of a pipe flange.

Handling the JIM system with the crane was a part of the training for complex task performance, requiring coordination and timing to assure safe lowering and raising of the system. The JIM operators were soon adept at system handling in laboratory and tank situations (Fig. 24), as well as in the open sea (Fig. 25). In the open-sea dive in the Gulf of Maine, accomplished in cooperation with the University of New Hampshire under NOAA sponsorship, operators in JIM successfully gathered water samples in bottles at 100 fsw.

Using an underwater voltmeter, JIM operators successfully demonstrated that they were able to read and report needle positions and values on the voltmeter. Another task, again involving the shackle, was a quasi-horizontal positioning of the system by the operator. The buoyancy of the suit is established within the range of each individual operator; weighting plays the major role. As noted earlier, operators in JIM were weighted to produce an in-water negative buoyancy of 60 lb. Operators learned to control their own buoyancy in the system so that they could "hover" in a quasi-horizontal position while performing a task.

One fleet-relevant task performed by JIM operators in the studies was the placement underwater of a power connector for a Deep Submergence Rescue Vehicle (DSRV), as shown in Fig. 26. It was assumed that in the event a submarine was incapacitated at great depths, a JIM operator might be able to assist in the placement of such a power connector; therefore, this task was developed with the cooperation of the Naval Civil Engineering Laboratory, Port Hueneme, California.

The nut transfer task involves a fine coordination task in which the operator in JIM, using his manipulators, lifts a 3/8-in nut from one spindle seated on the JIM Gym to another. As noted earlier, this task was performed in still water and under conditions of current, with success up to currents of 0.5 knots.

The manipulators are powered solely by the force of the operator himself and one assessment involved fine handling of the manipulators, specifically requiring the operator to pick up a flat washer from the deck, a task in which all operators succeeded.

Another fleet-relevant task was developed in cooperation with the Naval Air Station, Patuxent River, Maryland. An ejection seat in which a dummy pilot was strapped was placed on the bottom of the tank at Carderock and the operators in JIM, using their manipulators, were successful in releasing the buckle, freeing the "pilot" from the seat (see Figs. 27 and 28).

Earlier in this report the compression (or descent) and decompression (or ascent) times of JIM and divers in a saturation mode were compared. Again, it should be noted that at times the circumstances will dictate the choice between a dive using a JIM system and a dive using a saturation diver. One reason for such a comparison was that the Naval Sea Systems Command raised a question regarding the ability of JIM to place a DSRV power connector in the event of a disabled submarine.

With regard to a deep water accident, several factors were considered. The time to get a JIM to 1,000 fsw was shown to be between 5 and 10 min and, as has been noted, ascents of around 200 ft/min are obtainable once both front and back weights are jettisoned. The deployment of a JIM system was also analyzed in the project, both in a laboratory setting and during an open-sea dive; these times were recorded:

	Approx. Time
JIM completed disassembled, predive preparation from crate to assembly on stand	2 h
JIM assembled, on stand, from stand to water, operator in system	10 min
JIM in water, lowered to 1,000 fsw	10 min

A totalling of these figures shows that a JIM system could be lowered to the scene of a deep water (1,000 fsw) accident in less than 2 h 30 min. The Naval Sea Systems Command was interested in the possible use of JIM as an observation platform, in addition to the work platform concept, which is basic to the performance assessment. In other words, aside from performing work at depth, could JIM provide observation and documentation? This question was addressed in the

performance assessment by giving the operator in JIM a 35-mm still camera on one occasion and a 16-mm cine camera on another. Figure 29 shows the camera held by the operator, behind the JIM faceplate. Inasmuch as the arms of the operator can be removed from the JIM arms, holding a camera in such a fashion is no problem. Figures 30 and 31 show a photograph of the dummy pilot in the ejection seat taken by an operator in JIM in a tank, as well as a photographer taking pictures of JIM.

The potential value of having a JIM system available to photo-document an event appears very real. Adapting cameras and lights would be an important task if such an application were considered. The major advantage would, of course, be the speed with which such an endeavor could be mounted.

To return to a fine coordination task, the operators in JIM were able to tie a bowline with the manipulators (Figs. 32, 33); the fastest knot tying consumed 21 min.

One other fleet-relevant task completed quickly and efficiently was the simulation of a torpedo recovery; the operator was required to use an 8-in pipe, a padeye, and wire straps with clamps.

A final task in the performance series, though not done in the order discussed in relation to the other tasks, was the use of an air hose to fill and activate a lift bag to raise a drum from the bottom. As noted earlier, this task was successfully completed, but did generate the highest heart rates on first trial.

Sensory Feedback

The ability of the operator in JIM to perform in conditions in which sensory feedback is limited or distorted formed the basis for this portion of the biomedical assessment.

Inasmuch as there is no electrical power going into JIM and the operator is dependent solely upon his own tactile sensitivity in the use of the manipulators (no force feedback), as well as his own strength and dexterity to operate them, several experimental series were designed. The first was a study of psychophysical factors, of the ability to judge weights of sealed canisters with weights ranging from 5 lb to 0.5 lb (2.3 to 0.2 kg). The operator is asked to compare a given weight with a set standard and to judge whether it is lighter than, heavier than, or equal to the standard weight. This is a test of judgment that has a long history in psychophysics.

The results reported (Curley and Bachrach, 1981) that five male Navy-trained (4 Navy, 1 NOAA) divers each completed four sets of discriminations. On the surface, dressed in swimsuits, the operators correctly detected differences as small as 0.2 kg. In the JIM system underwater, the operators, using their manipulators, correctly discriminated differences of 0.7 kg or greater on a level greater than 80%; weight differences of 0.2 kg were correctly judged in 43% of the trials, as opposed to 100% on the surface. This percentage of 43% is

not significantly better than chance. Despite this decrement in psychophysical judgment from swimsuit on the surface to JIM in the water, it is nonetheless remarkable that the feedback through the manipulator's T-bar allows for sensitivities even in the 0.7-kg range. In this report, the subjects lifted the weighted sealed canisters from a box on the deck in a set order. In an earlier version of the experiment the operators picked up the canisters and held them outstretched in making the judgments (Fig. 34). In both cases similar sensitivities were found.

Another related study on tactile sensitivity was reported in the same paper by Curley and Bachrach (1981). This study dealt with tactile sensitivity in identifying objects under water under conditions of degraded visibility. The same subjects, five male Navy-trained (4 Navy, 1 NOAA) divers, were used in this experiment as in the psychophysical judgment experiment. In this study, five common objects were selected as targets for identification (Fig. 35). The faceplate of JIM permitted the insertion of filters made of Mylar A plastic, cut into circles 18.5 cm in diameter (a technique suggested by John Merritt). This plastic had translucent "milky" qualities and, as judged by experienced divers, best simulated the qualitative visual distortion and degradation encountered in turbid water. There were four filters in all. Figure 36 shows the four filters superimposed so that the congruence in the center represents the ultimate in degraded visibility through filtering; the edges represent the single filter with lowest degradation. The filters could be inserted one at a time in layers in the faceplate. The decrement in luminance was measured by a silicon cell spotmeter. As the article reports, approximations to the luminance reduction found underwater were made on the surface with the plastic filters 20 cm from the spotmeter lens and in line with a target (a screw-pin shackle) 14 cm from the filters. The screw-pin shackle is shown in Fig. 37 with no filter imposed, in Fig. 38 with one filter, in Fig. 39 with two filters, in Fig. 40 with three filters, and, finally, in Fig. 41 with four filters. The spotmeter luminance assessment revealed a reduction of 48% with three layers and a reduction of 61% with all four filters. The subjects reported that they could not identify any of the target objects at a distance of 6 cm from the viewport with all four filters in place.

During the experiment filters were placed in the viewport on the surface and two objects were lowered into the water and placed on the pool bottom. The diver-operators had been shown the five objects before the start of the experiment during the instruction period. Given voice instructions to lead the operator to the objects, each operator in JIM was instructed to use his manipulators and identify, over his voice communicator, the objects on the bottom. The operators were able to identify the objects in 13 of 17 trials (76%) with all four filters in place in the viewport, solely (it is presumed) by tactile feedback through the manipulators from contours of the object. This experiment and the related study of psychophysical judgment both serve to indicate that tactile sensitivity is good with the presently used manipulators; the problem of degraded visibility is thus minimized to some degree.

Visual Field Examination

Data from preliminary visual field examinations, using perimetry, showed that the operator, with head stationary and fixed with front orientation, had good peripheral vision. With even minor head movements the placement of the ports permitted a 270° visual field. The Type-IV JIM with the WASP dome (Fig. 3) should permit more visual field coverage.

Environmental Variation

Effects of current have been discussed earlier. As a brief summary of findings regarding performance in current, it appears that operators in JIM are capable of performing tasks of varying levels of complexity as well as maneuvering against a current with no significant difficulties until the level of current reaches 0.75 knots. At a level of 1 knot operators could maneuver the circling line, using manipulators hand-over-hand, but that is the only task successfully completed at 1 knot.

Effects of temperature. As noted in the diving history of JIM, a dive in 1976 in the Canadian Arctic was accomplished by an operator in JIM who worked for a total of 5 h 59 min at 905 ft in water temperatures of 27.5° F. (Ca. -2° C). Cold waters, therefore, do not appear to be a major problem.

The very success of the JIM operator in working in cold water posed a question during a conversation with Dr. David Youngblood of Oceaneering, International. The question arose as to whether the advantages of JIM's stabilization from body heat and CO_2 scrubbers in cold waters might become a disadvantage in warm waters, for, just as there is no internal heating in JIM, neither is there any provision for internal cooling. A related question posed was whether there would be a significant problem in warm water at the depths JIM would be likely to operate. A glance at the Diving History (Table 3) shows that the operating depths for JIM are generally deeper than 400 fsw. Information obtained from the National Oceanographic Data Center indicated that a deep diving system could encounter warm waters even at great depths, particularly in areas such as the Red Sea and the Indian Ocean where temperatures near the surface average 95° F (35° C), and even at 1000 fsw it is possible to encounter water temperatures around 72° F (24° C).

In a series of experiments on hyperthermic effects on performance accomplished under Project ADS, (Curley and Bachrach, paper submitted for publication) five Navy-trained divers (4 US Navy, 1 NOAA), who were experienced in operating JIM, were tested in two levels of water temperature in an indoor test pool at the Navy Experimental Diving Unit; the water temperatures were mild (20° C, 68° F) and warm (30° C, 86° F). Each operator completed a series of three dives at each water temperature. The tasks consisted of tasks previously done and included 60-ft walks and three sets of step maneuvers on the JIM Gym. Heart rates (HR's) and respiration rates were taken on each dive, along with core temperatures (rectal) and cabin temperatures. The latter was measured by a thermistor placed about 5 cm above the operator's forehead in the

dome of the JIM. Among the data was the finding that walk completion times were slightly faster at 30° C (mean time = 68.4 sec) than at 20° C (mean time = 71.1 sec), although HR's were higher at 20° C during walks (mean = 135.3) than at 30° C (mean = 127.9). The step maneuver on JIM was the most difficult task for the subjects. Even here, the completion times were faster at 30° C (mean = 64.5 sec) than at 20° C (mean = 99.5), with slightly higher HR's at 30° C (mean = 151.5) than 20° C (mean = 145.8). The mean heart rate of 151.5 was for the first 60 sec of the task in 30° C water. These heart rates rose during the course of the task. Respiration rates were relatively high for all operators under all conditions and did not seem to be a function of task or temperature, running on an average of 27 to 28 breaths/min. This appears to reflect marked exertion. In a debriefing the operators indicated that they felt a certain discomfort in not being able to obtain sufficient air to meet the task demands. A recommendation for reconfiguring the breathing system, e.g., the oral-nasal mask, was found in all operator reports, postdive.

Four of the five operators reported that they were uncomfortably hot under the 30° C conditions and the levels of activity required. One conjecture regarding the faster task completion times under the warmer water temperatures was derived from the expressed desire of the operators to get the tasks done as quickly as possible because of the discomfort. Another conjecture is that the lowered viscosity in the warmer water (a factor of 20%) might have made the movements a bit easier. In any case, the expressed discomfort coupled with the high heart rates on the step maneuver at 30° C is a source of concern.

Cabin temperatures in JIM under these water conditions are also a source of concern. Cabin temperatures rose from a mean temperature at the start of the dive of 27.4° C (Ca. 81° F) to a mean temperature of 32.6° C (Ca. 90° F) after a 40-min dive. The highest cabin temperature recorded on any one dive was 34.0° C (93.2° F) after 35 min. Rectal temperatures did not vary significantly from beginning to end in the dives; the mean core temperature at start = 38.1° C, at the end of the dive = 38.2° C; the dives lasted from 30 min to 40 min.

The 30° C data are summarized: during a vigorous 40-min dive in JIM with tasks requiring effort and exertion, mean values for heart rates were 151 beats/min; mean values for respiration rate were 28 breaths/min, cabin temperature mean was 32.6° C, and rectal temperature means were 38.1° C. There was no direct comparison during Project ADS between these hyperthermic water data and the results obtained, for example, in measuring heart rates during other, cooler water exposures; however, it is clear that the warmer water temperatures induced greater physiological effects than temperatures experienced in other situations doing the same tasks. At the Circulating Water Channel, Carderock, the water temperatures in the nonheated pool ranged around 10° C to 15° C, and Langworthy, Bradley, and Bachrach (1979) reported that heart rates at the beginning of tasks ranged from 132-162 on the walk (mean = 148). This mean heart rate is comparable to the mean obtained in the 30° C water and, in both cases, represents a response to exertion. The respiration rates in the Carderock series were also high in all operators (up to 32 breaths/min). But, as Langworthy, Bradley, and

Bachrach (1979) reported, there was adaptation, and both heart rates and respiration rates came down significantly, presumably as a function of experience. Thus, it is of interest that the operators in the hyperthermic studies, who all had experienced a minimum of 20 dives in JIM, had heart rates that were high on initial exposure and, under some conditions, actually rose during the dive rather than settle to a lower level. This is interpreted as a function of warm water requiring exertion and inducing discomfort.

Life Support

The work on life support was a preliminary examination of techniques for measuring physiological functions in the laboratory, as well as methods for in-water monitoring. JIM's breathing system was evaluated to determine the carbon dioxide and oxygen percentages in the oral-nasal mask and in the cabin atmosphere. Our understanding with the manufacturers of JIM was that we would make no alterations in the integrity of the system, such as penetrations other than those already provided. Other changes were made as, for example, in the shift from the oral-nasal mask that came with the JIM system to a Scott U.S. Navy Aviator's Mask, which proved to be more comfortable for long exposures (Fig. 42). Masks were adapted for the operators from the Scott mask so that they would be operator- and system-compatible. Future analysis of the mask appears indicated on the basis of comments emerging from the hyperthermic studies. Another change that we made, not related to life support, was to lower the placement of weights on the front and back of JIM to provide more stability for the operators. Again, this change in no way violated the integrity of the system.

Evaluation of the carbon dioxide and oxygen required the in-house design of a closed-loop gas-analyzing system (Langworthy and Flynn, 1979). This closed-loop system ensures against loss of a fixed gas volume and permits monitoring the gas concentration of either gas in the operator's mask or in the cabin atmosphere. Figure 43 shows the mask in the laboratory study with the sample pickup valve. This closed-loop gas-analyzing system allowed monitoring in the laboratory or during shallow submergence.

As part of the techniques for monitoring the cabin environment. we installed an ACDM Beckman carbon dioxide analyzer, a Teledyne oxygen clip-on analyzer worn by the operator, and YSI thermistors for monitoring core and cabin temperatures.

Resistance and flow rates of the breathing gas system were measured with the exhalation and inhalation canisters dry and full, wet and full, and empty. The results indicate that the systems provide adequate flow rates and the resistance characteristics of the JIM breathing system fell within acceptable limits. These measurements were accomplished using a Fleisch pneumatic and Valdyne differential pressure transducer along with a two- channel Brush recorder.

These laboratory and shallow water studies should certainly be implemented by deep water analysis under varying conditions.

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APPENDIX A

FIGURES CITED IN TEXT

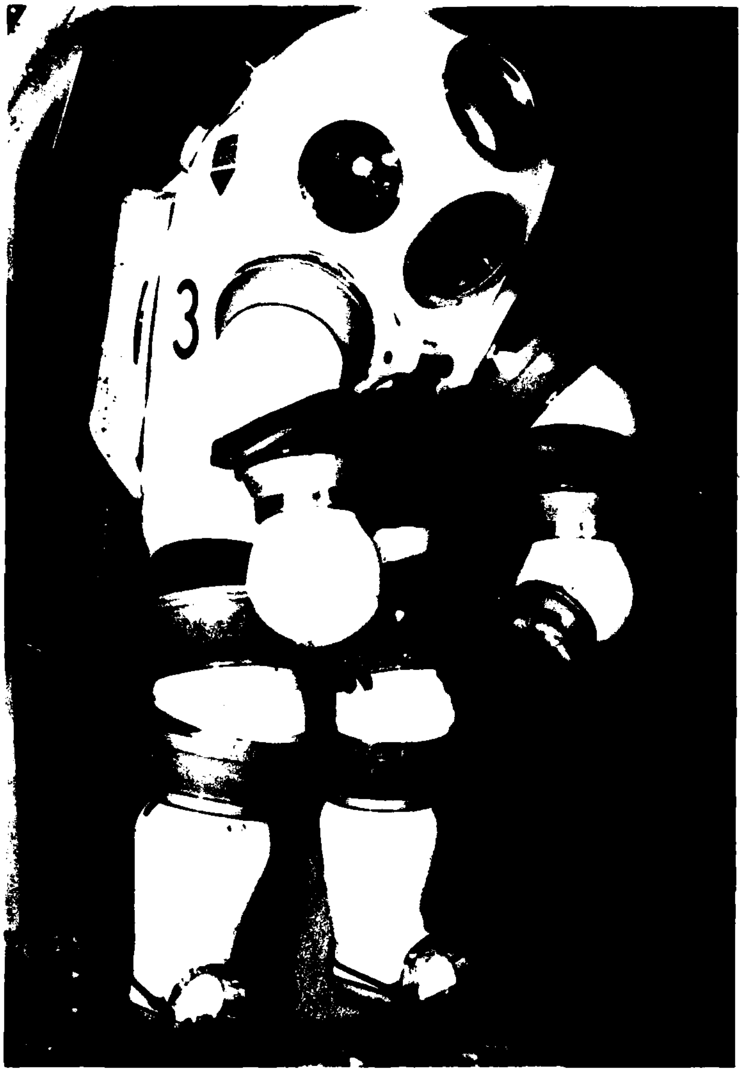


Fig. 1. JIM-3 ADS.

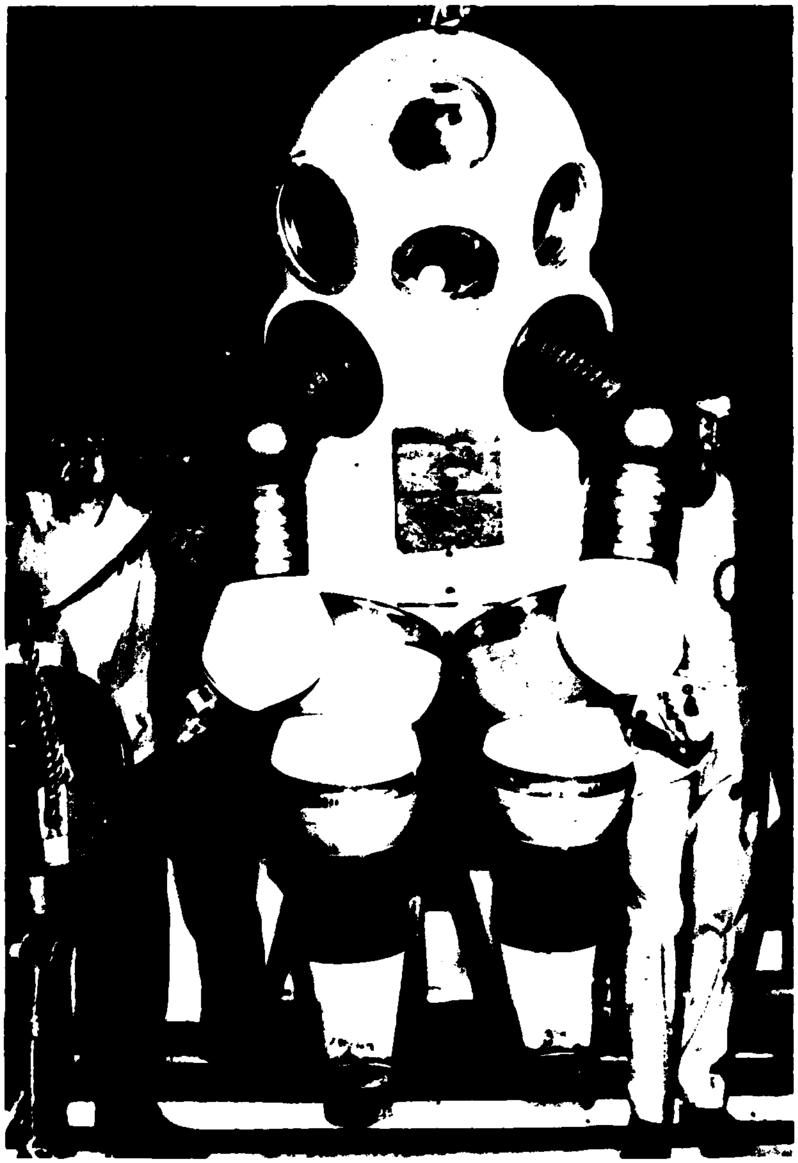


Fig. 2. JIM-4 ADS.

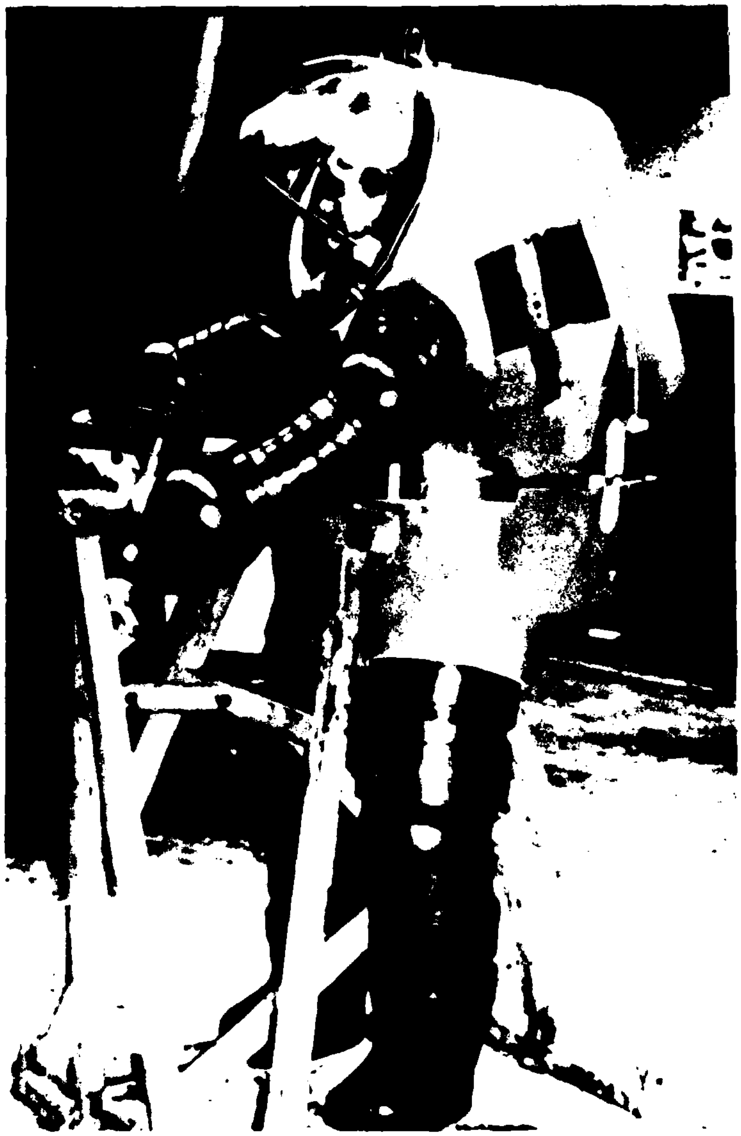


Fig. 3. Type-IV ADS (fiber glass body).
(Courtesy Oceaneering International, Inc.)

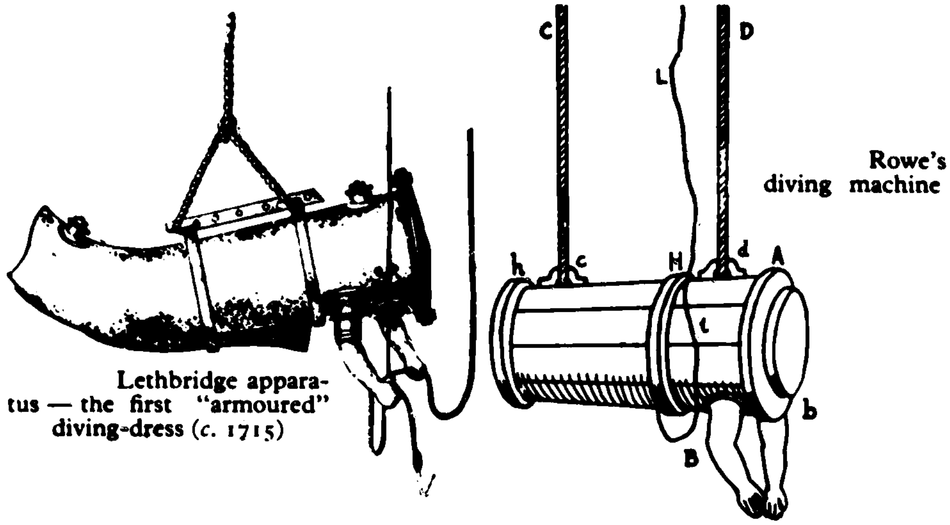


Fig. 4. Lethbridge* and Rowe diving machines.
(*Design re-created by Pesce, cited in Davis, 1969)

Fig. 5. ADS WASP.
(Courtesy Oceaneering International, Inc.)

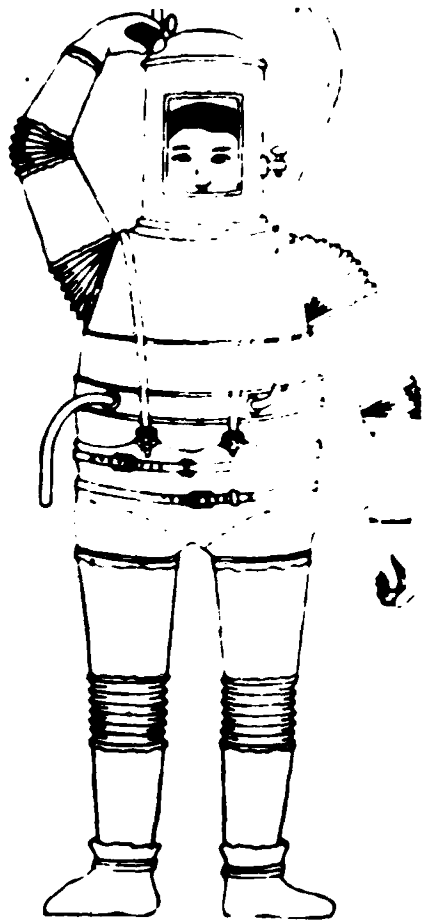


Fig. 6. Taylor's first articulated diving dress, 1838.
(From Davis, 1969)

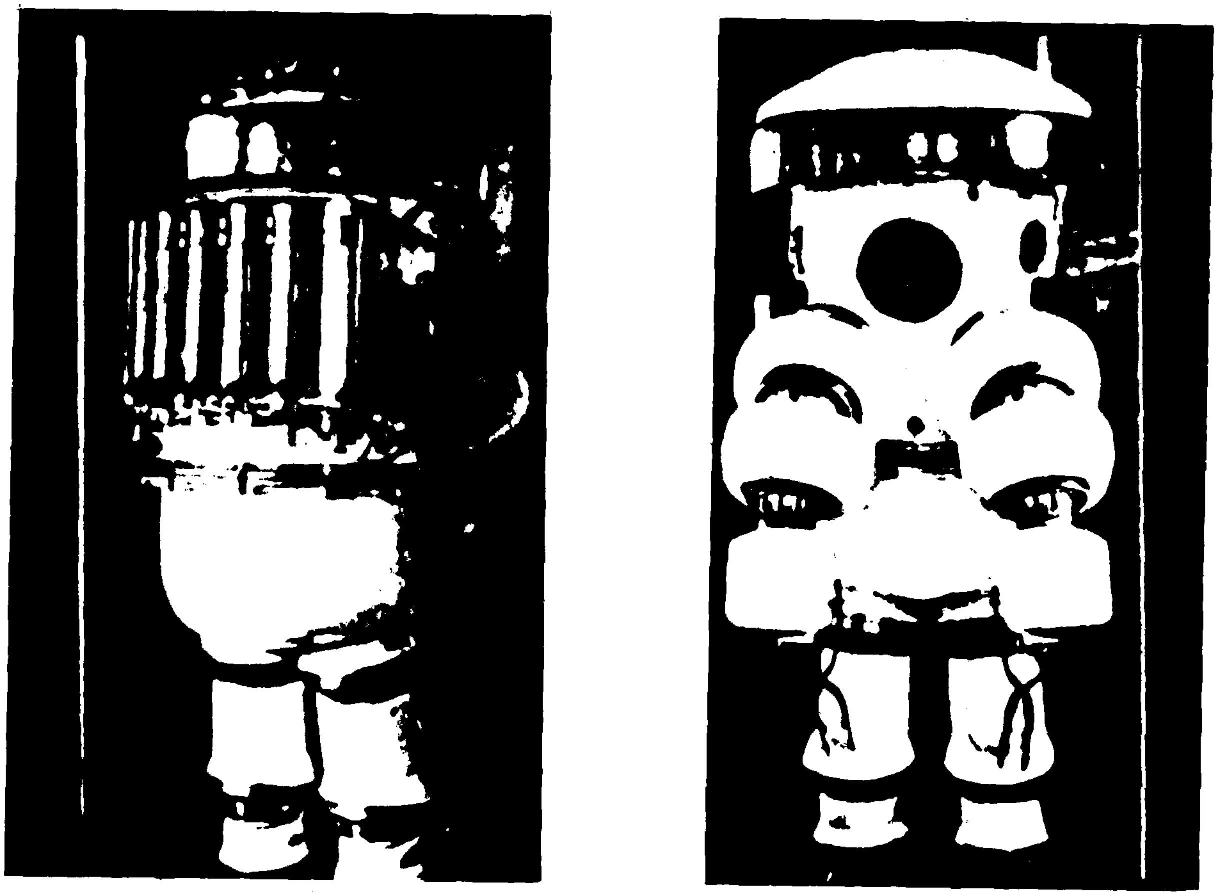


Fig. 7. Neufeldt and Kuhnke diving dress.
(From Davis, 1969)

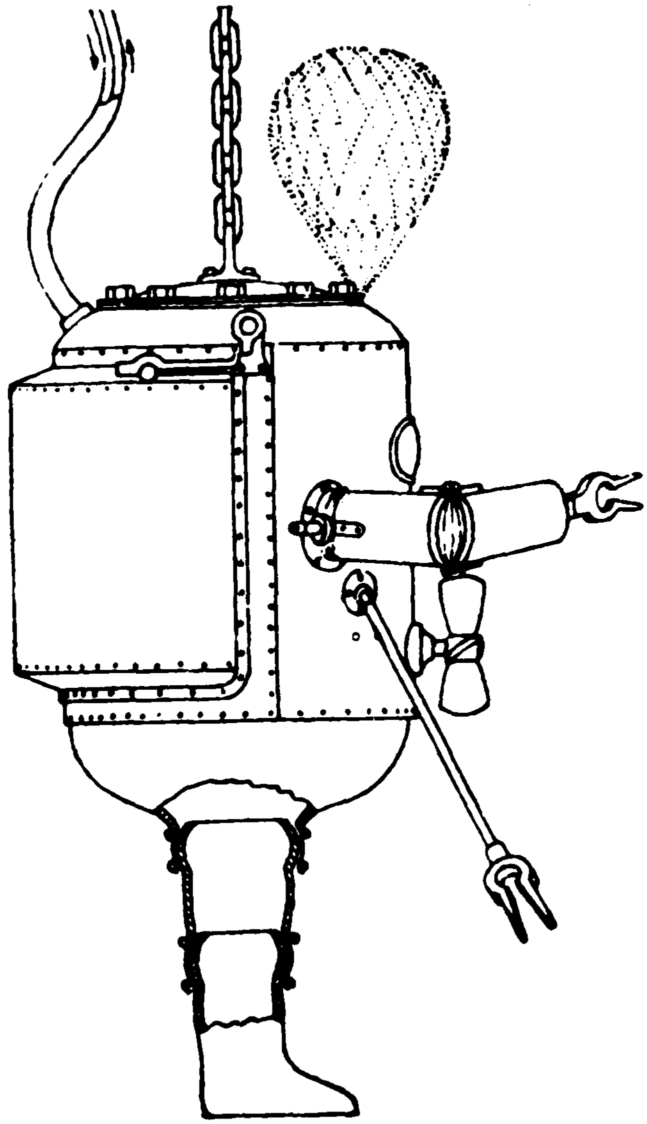


Fig. 8. Philips diving dress.
(From Davis, 1969)

Fig. 9. Galeazzi diving suit.

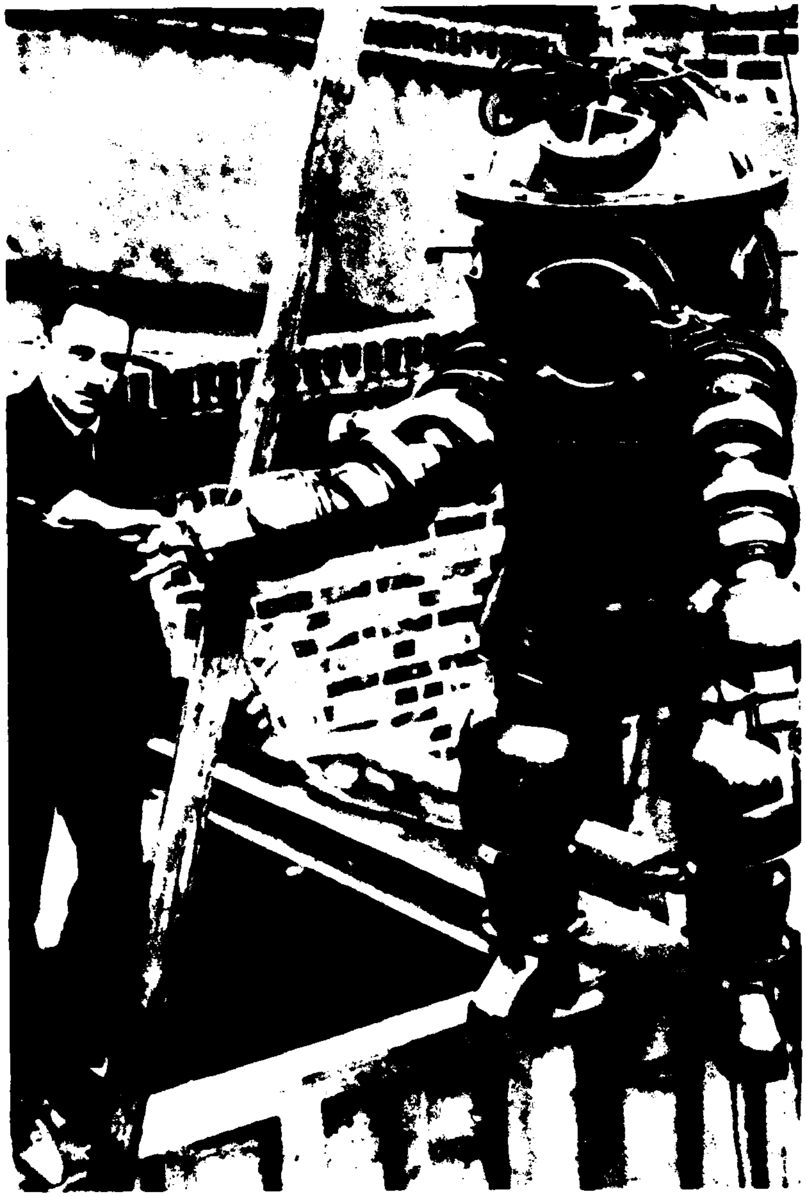


Fig. 10. Peress's diving system, the TRITONIA.

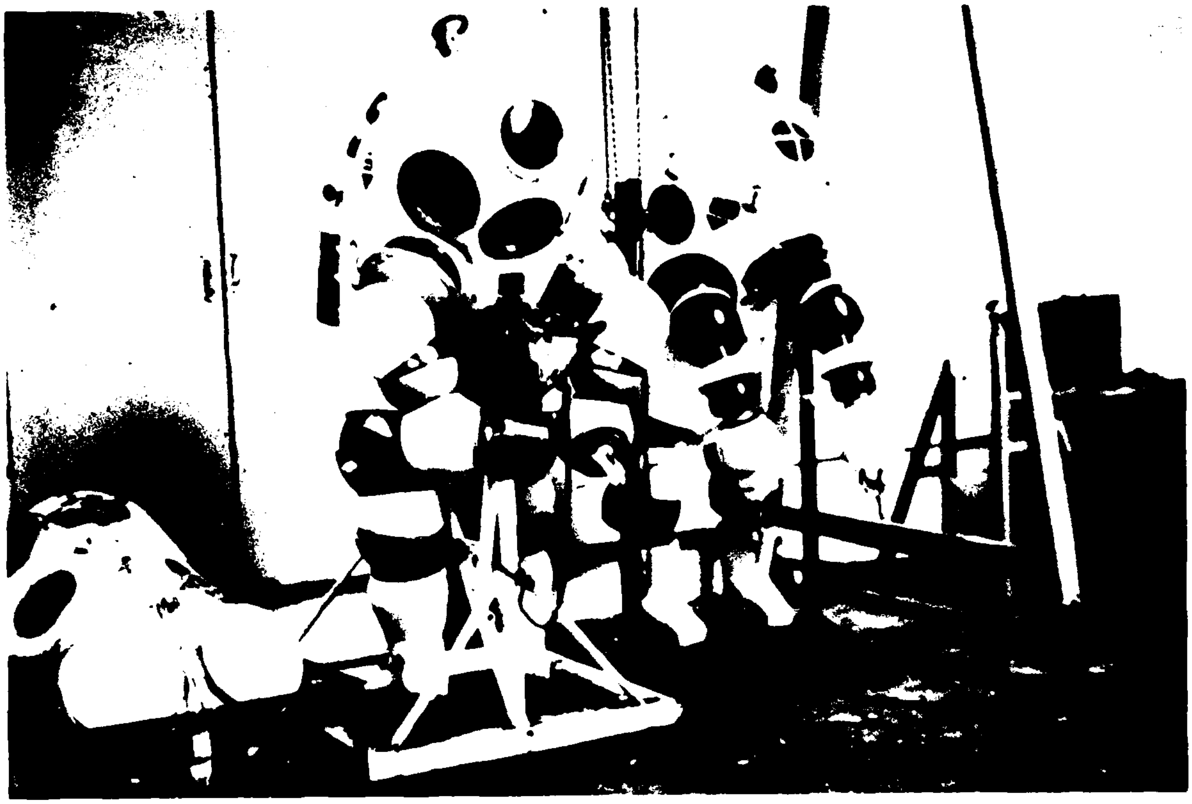


Fig. 11. An early version of JIM (left) and TRITONIA.

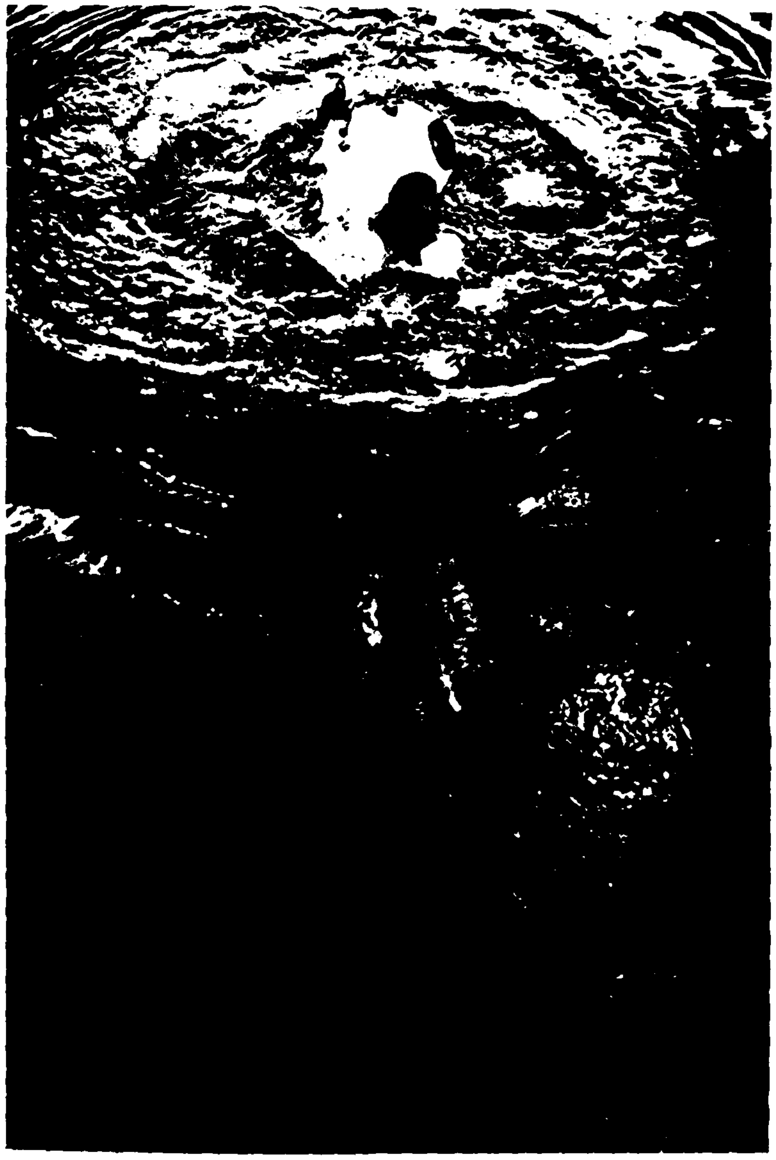


Fig. 12. Diver emerging in JIM-4 after ascent.

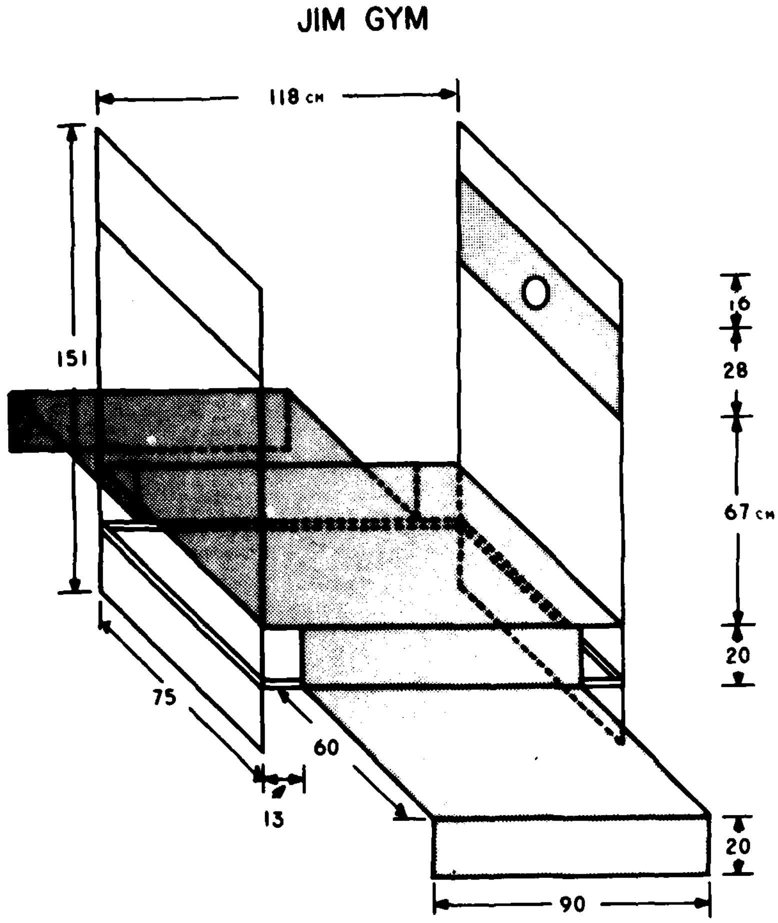


Fig. 13. JIM Gym.

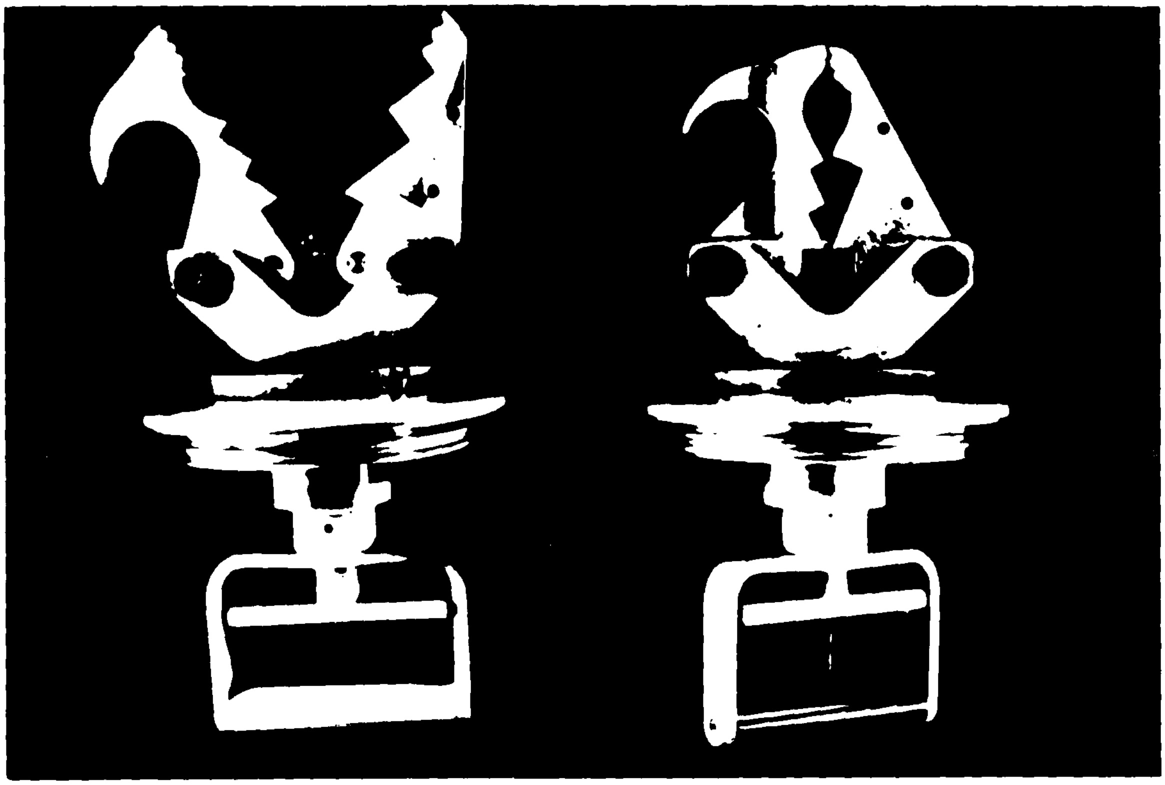
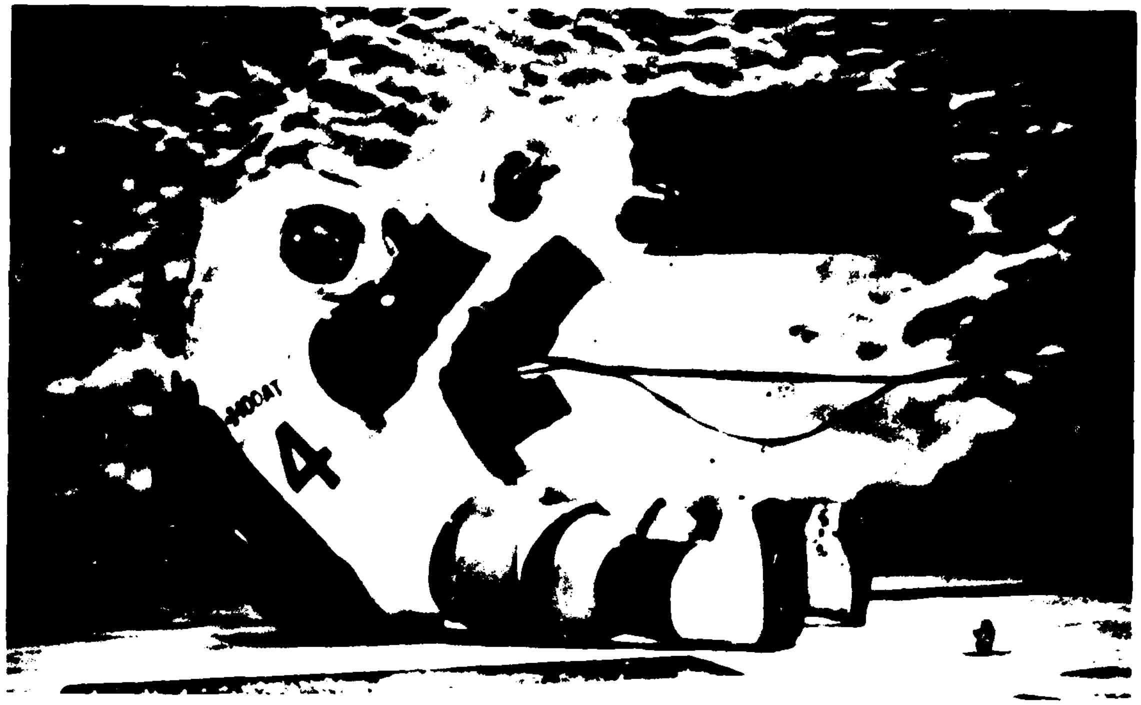


Fig. 14 (top) shows JIM-4 manipulators.
Fig. 15 (bottom) shows a JIM-4 operator walking against a 0.75-knot current.



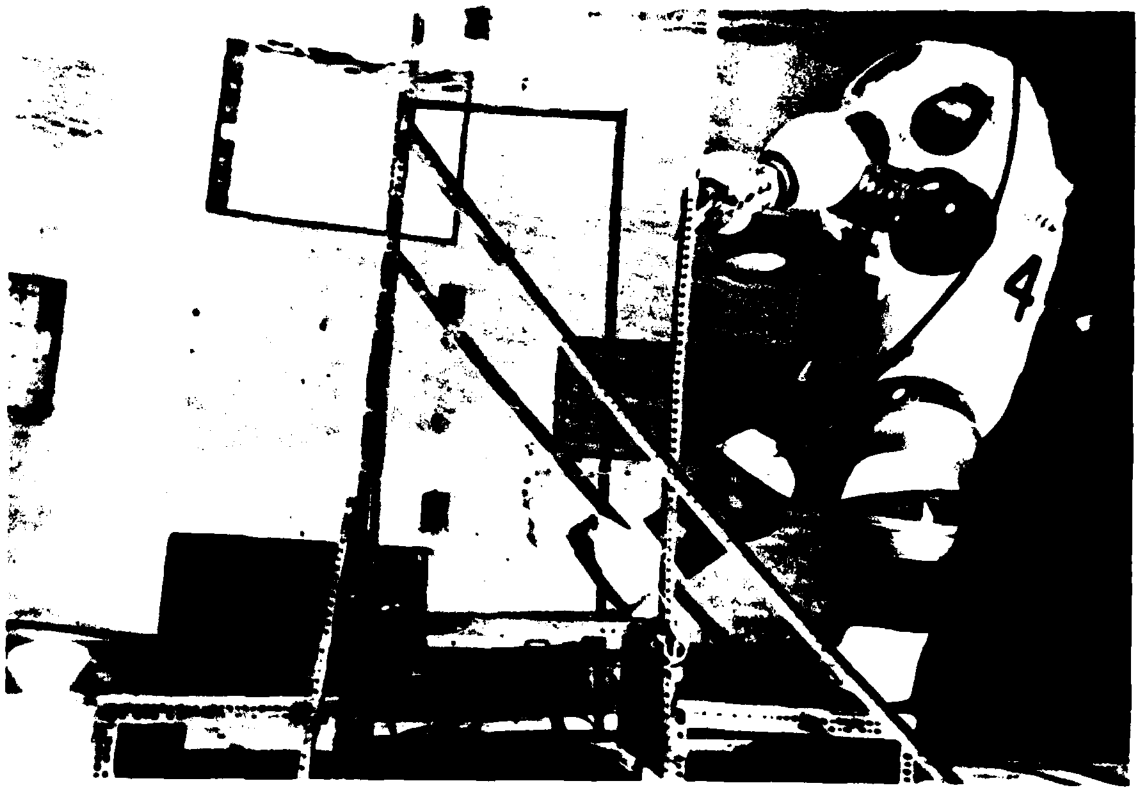
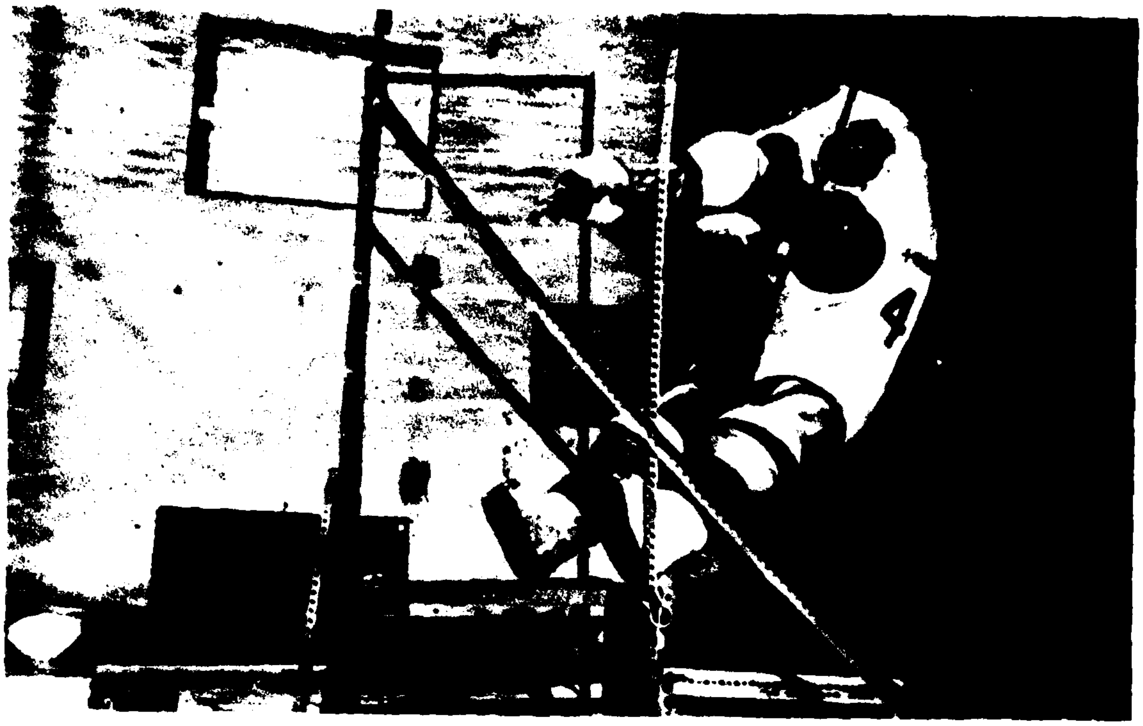


Fig. 16. (top) JIM-4 operator preparing to restore balance after falling backward.

Fig. 17. (bottom) JIM-4 operator walking on JIM Gym.



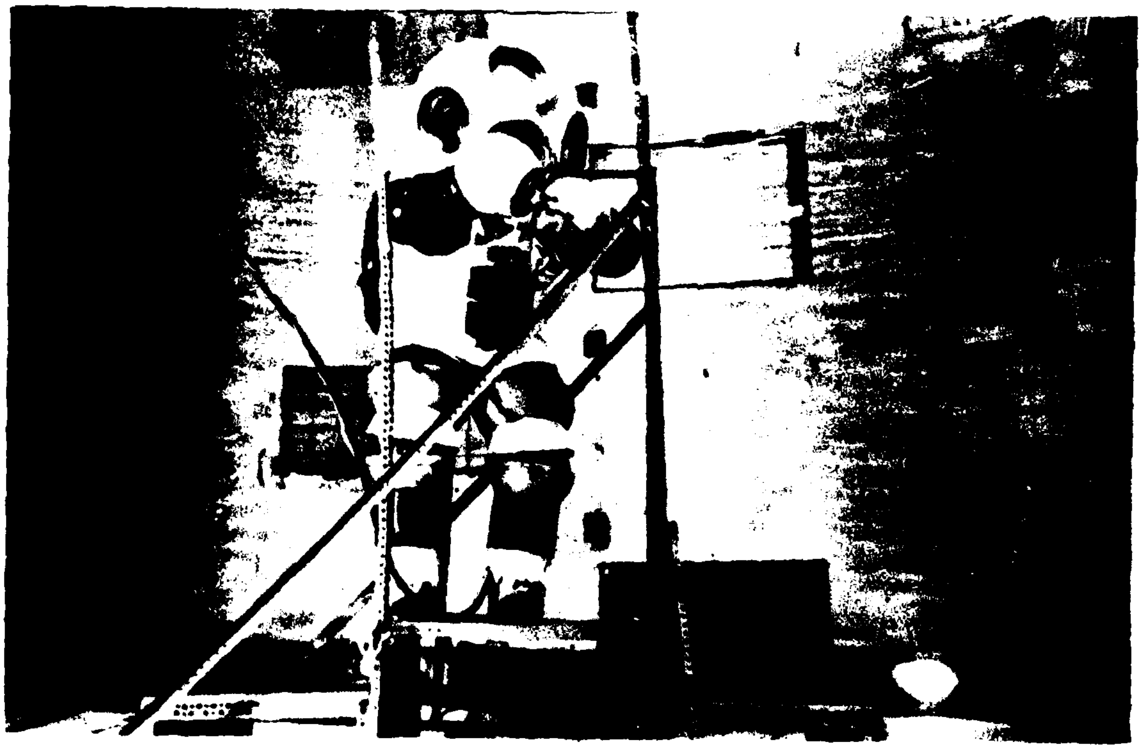


Fig. 18. (top)
Fig. 19. (bottom) JIM-4 operators walking on JIM Gym.

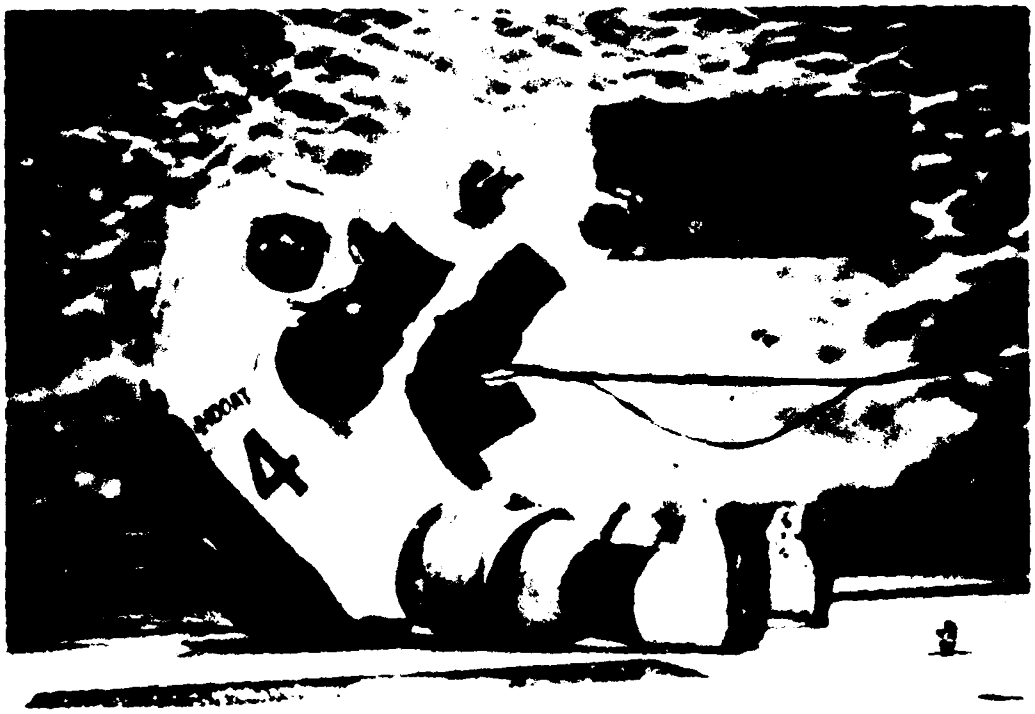
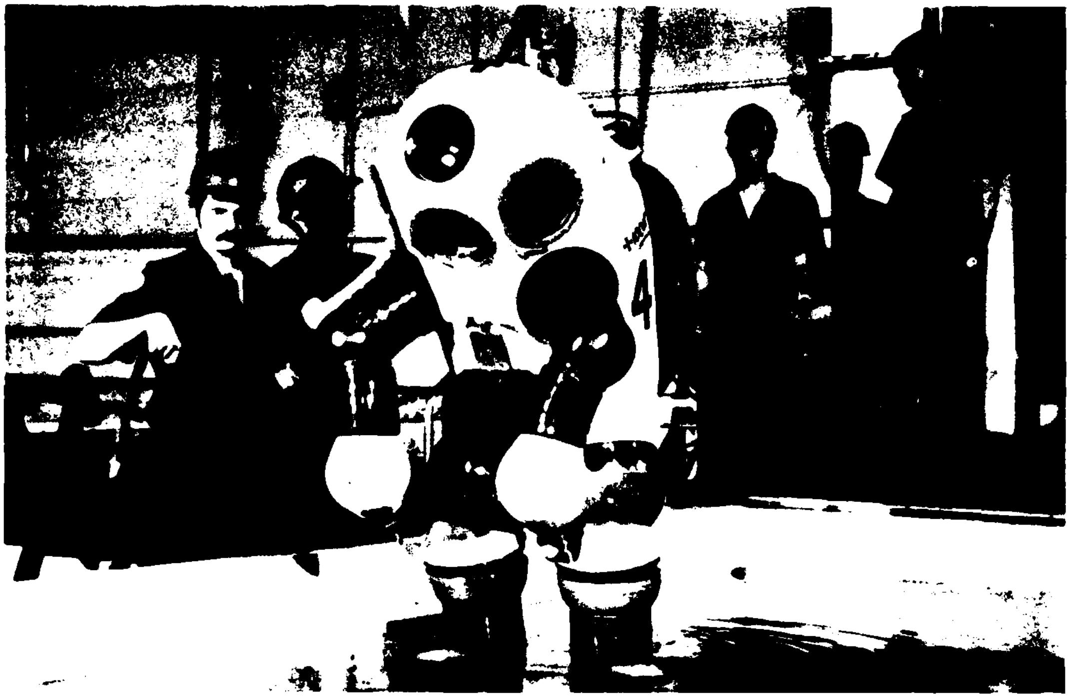


Fig. 20. (top) JIM-4 operator rolling system over on deck from supine position (part of maneuvers also illustrated in Fig. 16)

Fig. 21. (*bottom*) JIM-4 operator traversing a circling line against a current set at 1.00 knot. (Photographed from TV monitor)

Fig. 22. (top) JIM-4 operator turning a gate valve. (Photographed from TV monitor)

Fig. 23. (bottom) JIM-4 operator placing shackle on a plate.



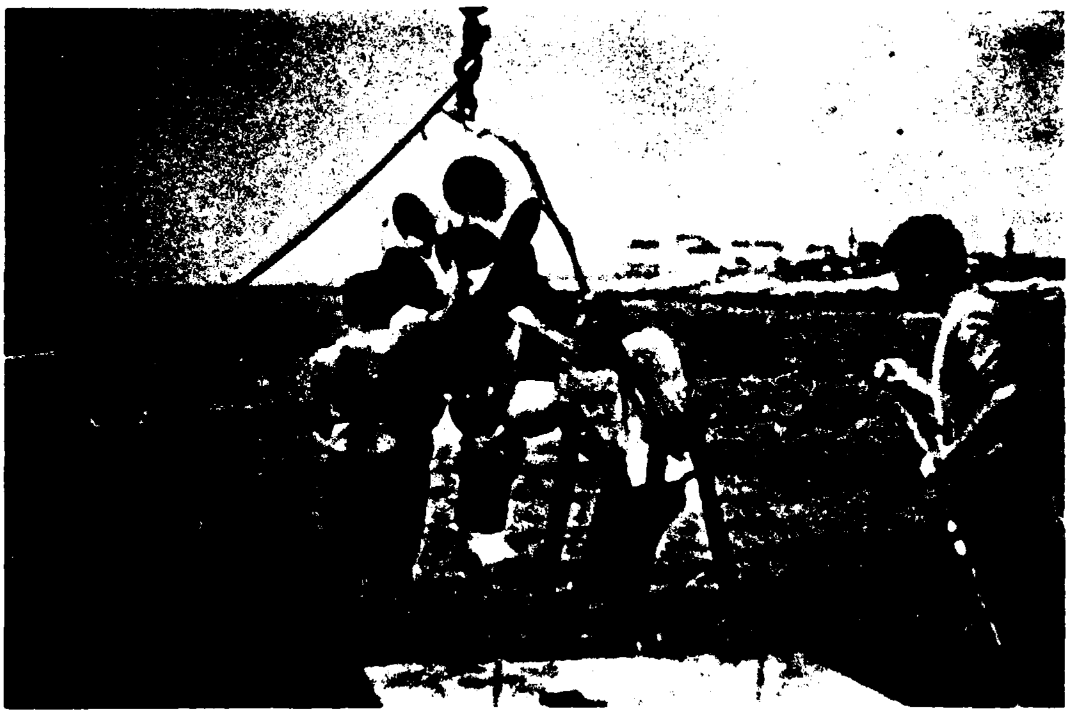


Fig. 24. (top) JIM-4 system handling in laboratory conditions.
Fig. 25. (bottom) JIM-4 system handling in open sea.

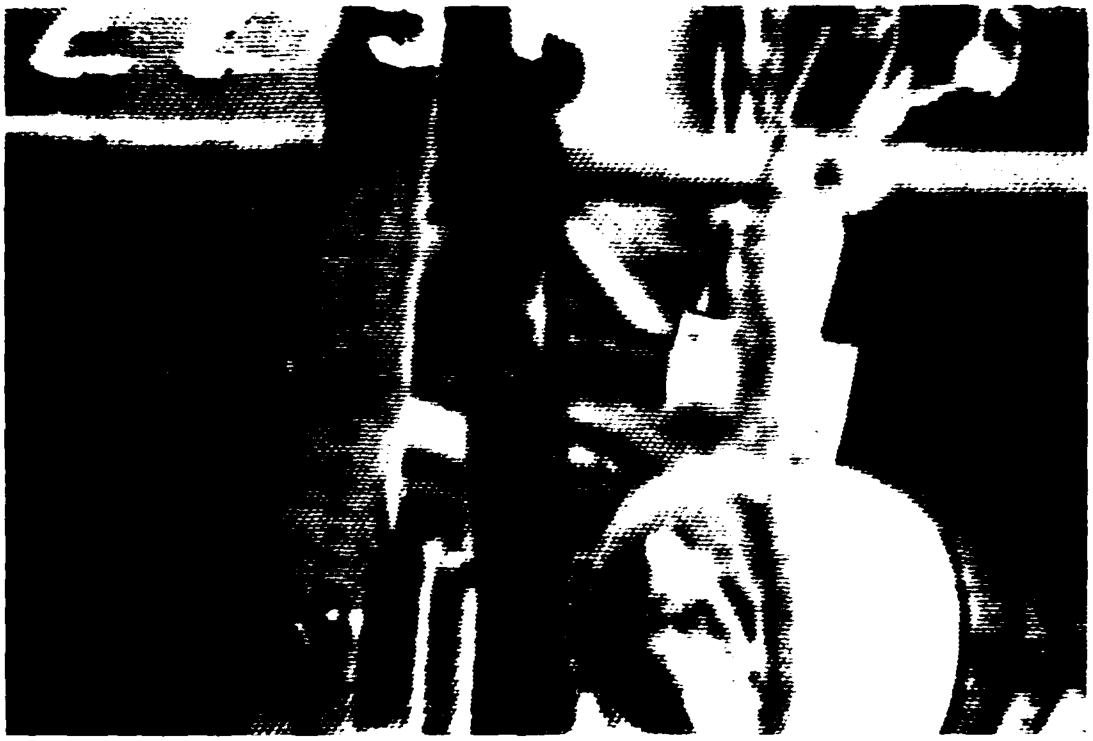


Fig. 26. (top) JIM-4 operator placing power connector for a DSRV. (Photographed from TV monitor)

Fig. 27. (bottom) JIM-4 operator releasing dummy "pilot" from seat.

Fig. 28. Another view of JIM-4 operator releasing dummy "pilot" from seat.

Fig. 29. (top) JIM-4 operator holding camera behind faceplate.

Fig. 30. (bottom) Photograph taken by JIM-4 operator from inside system.

Fig. 31. Photograph of dummy "pilot" and diver taken by operator from inside JIM-4 system.

. 32. JIM-4 operator tying bowline.

Fig. 33. JIM-4 operator tying bowline.

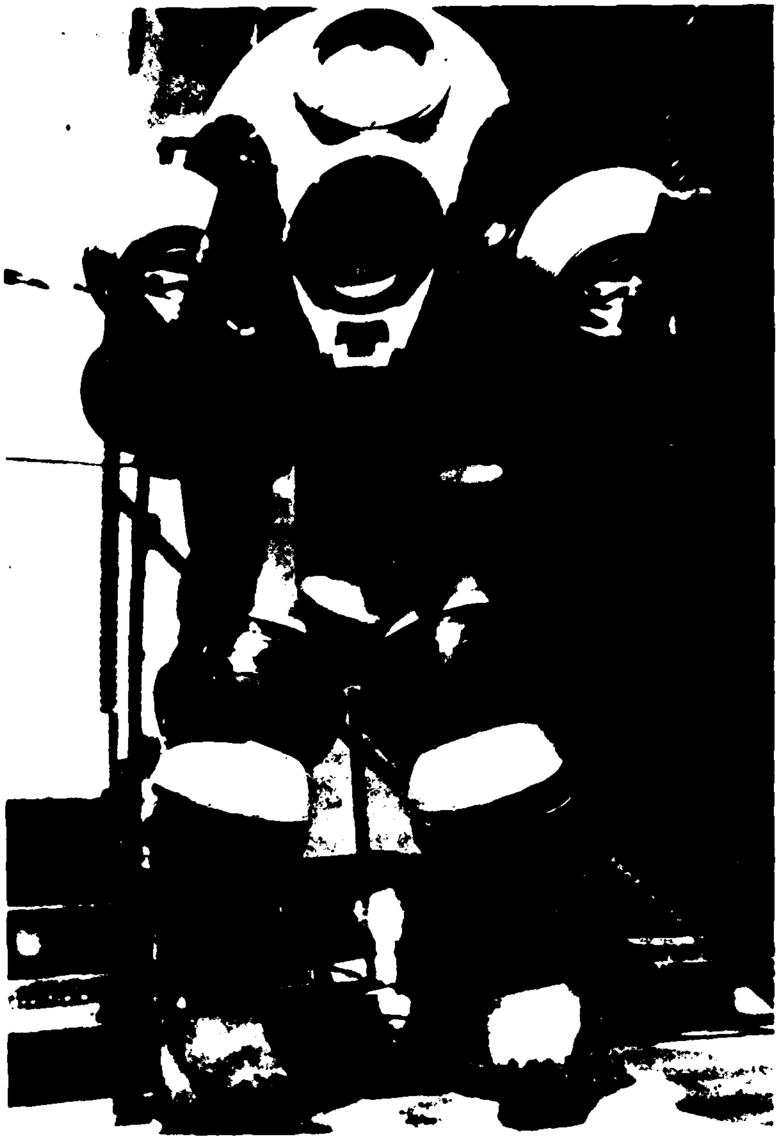
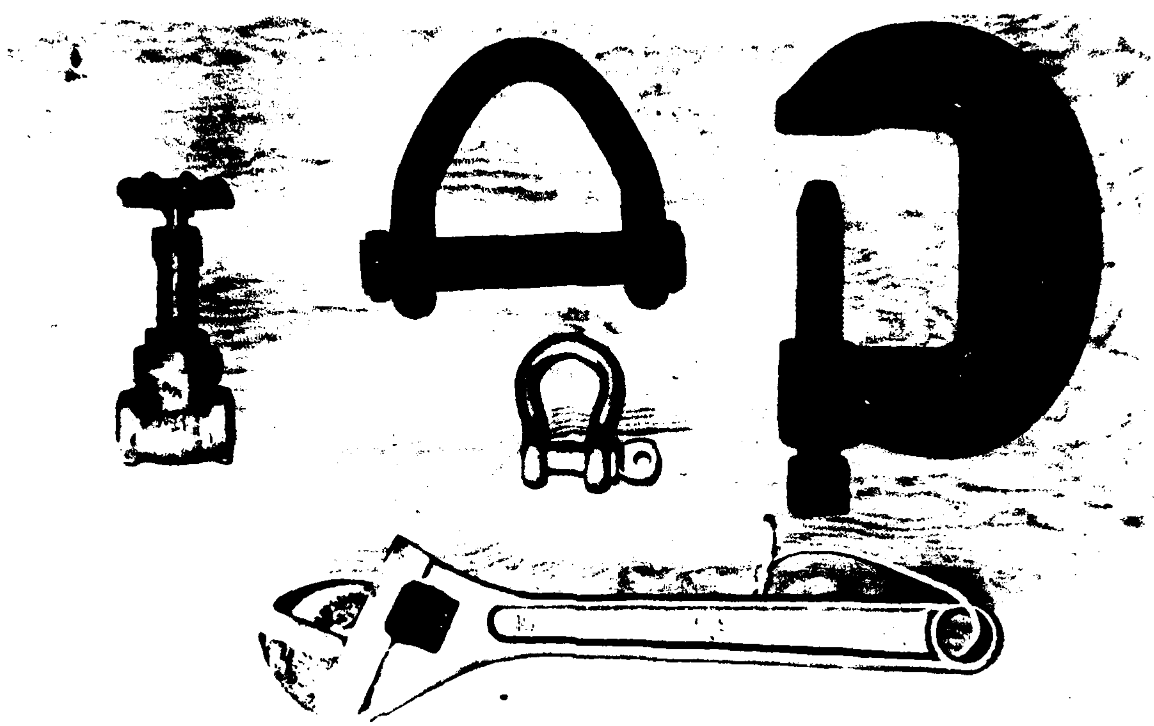


Fig. 34. JIM-4 operator judging weights of canisters.



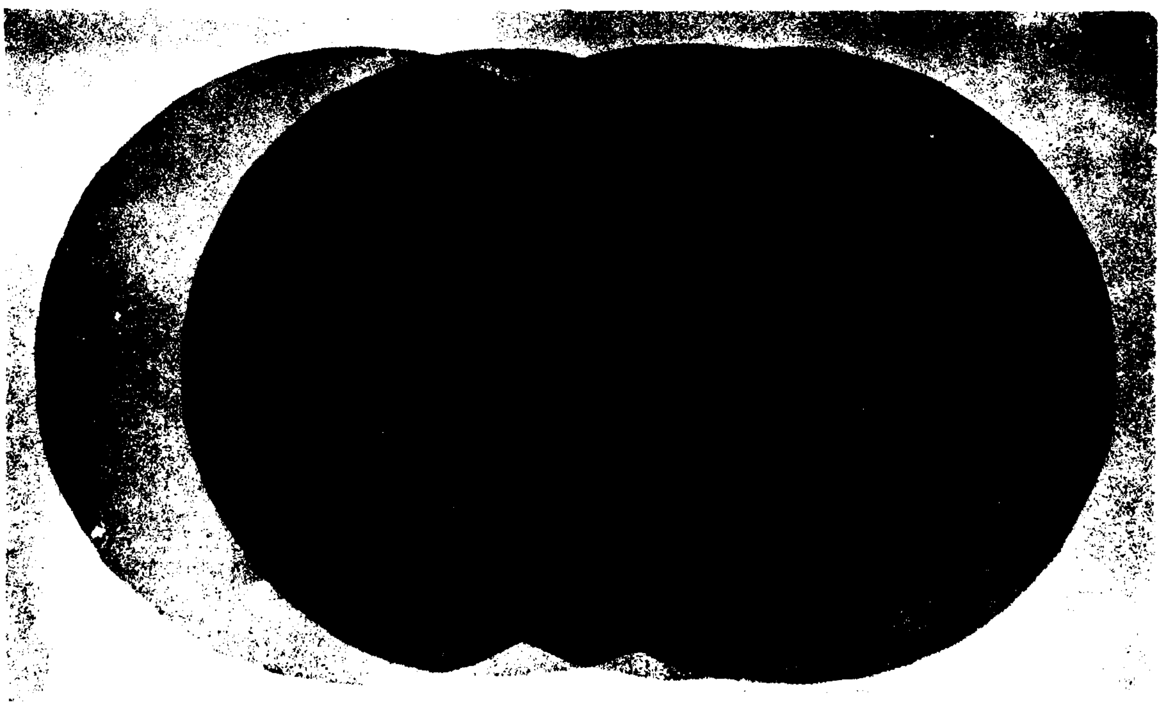


Fig. 35. (top) Objects to be identified under conditions of degraded visibility.

Fig. 36. (bottom) Filters used in faceplate are superimposed to show ultimate degraded visibility in water.

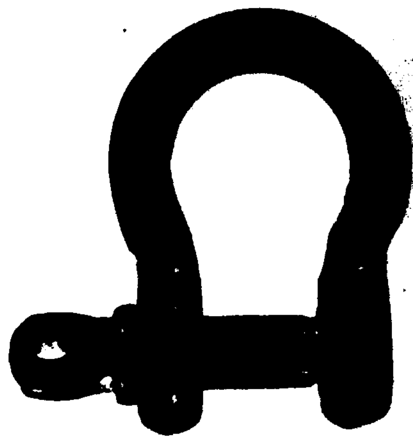
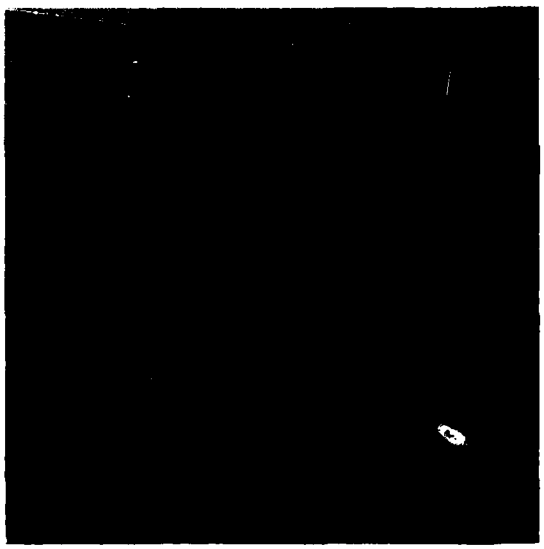


Fig. 37. (top) Screw-pin shackle as it appeared with no filter imposed on faceplate.

Fig. 38. (bottom) Screw-pin shackle as it appeared with one filter imposed on faceplate.



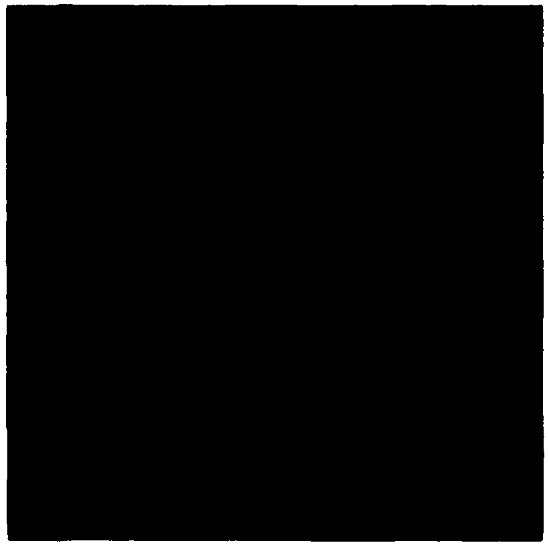


Fig. 39. (top) Screw-pin shackle as it appeared with <u>two</u> filters imposed on faceplate.

Fig. 40. (bottom) Screw-pin shackle as it appeared with <u>three</u> filters imposed on faceplate.

Fig. 41. (right) Screw-pin shackle as it appeared with <u>four</u> filters imposed on faceplate.

Fig. 42. (top) Scott U.S. Navy Aviator's Mask that replaced standard JIM mask.

Fig. 43. (bottom) Oral-nasal mask with sample pickup valve for monitoring gas volume and concentration.

APPENDIX B

PROCEDURES

Procedures developed for submission to Naval Sea Systems Command, Systems Certification Authority (SCA), in accordance with NAVSHIPS 0900-028-2020 "Pre-Survey Outline Booklet for Manned Non-Combatant Submersibles."

Prepared by

Charles Flynn

John C. Naquin

Ser 11491

PRESSURE HULL

For Use With ADS #4

Submitted By: DATE:____________

Approved:______________________________ DATE:____________
Diving Officer

This section details characteristics of the pressure hull and testing procedures.

Enclosure (1)

Pressure Hull

All metallic parts of the ADS which may come into contact with water or which may be subject to corrosion due to electrolytic action re protected by special surface treatment.

(A) Body and Dome

The body and dome are cast from a Magnesium Alloy RSS which is surface treated before and after machining with an HAE process, which considerably increases the surface hardness.

After machining and HAE treating the surface is sealed with five coats of Epoxy Resin, each coat of which is stoved to give a hard finish, Final treatment consists of two coats of Epoxy Primer followed by four coats of a chemical resistant gloss.

If damage occurs to the coating, the corroded or damaged area must be physically scraped clean. Great care being taken to remove all signs of corrosion. The area in question is then cleaned with a suitable degreasing agent and is filled with a Twin-Part Epoxy Adhesive (e.g. Araldite) and coats of Epoxy Primer and Gloss are applied.

In very serious cases of damage or corrosion, but where no loss of structural strength has occured, the damaged areas may be repaired using cosmetic welding. The procedure is very specialized and involves Argon Arc Welding.

(B) Boots, Legs and Knee Spacers

These components are cast from a high corrosion resistant aluminum alloy (2L99).

After machining they are hard anodized and coated with two coats of Epoxy Primer followed by four coats of a chemically resistant gloss.

(C) Arm Enclosures

These are made from Glass Reinforced Plastic (GRP) with aluminum insert Rings at either end for attachment to adjacent joints.

Pressure Hull

The aluminum insert Rings are machined from standard HE15 Bar and are soft-anodized before they are bonded to the GRP. After necessary dressing operations, final treatment consists of a primer coat, two undercoats and one top coat of a polyurethane paint.

(D) Viewports

The viewports are made of plexiglass and are curved to give optical correction. They mate into taper bores which are machined and lapped in the dome and are additionally sealed by o-ring seals at the external edge.

Manipulators

The standard ADS manipulator may be opened, closed and rotated. Different types of jaws may be fitted depending on the work to be carried out. But in essence jaws are fitted as pairs with serrated edges and/or additional lugs. The manipulators assembly is connected to the hand enclosure by a special disc.

Rotary movement and opening/closing of the manipulator jaws is achieved through a system of pins, bushes, bearing pads, thrust washers and O seals from handles in the enclosure. Rotation of the outer handle causes rotation of the manipulator jaws, while opening/closing of the jaws is achieved through either longitudinal movement of the inner handle in a quick "in/out" mode or by slow rotation.

In order that a special pin may easily slide between the various sleeves and bushes which surround it, it is necessary that it be balanced hydraulically, and this is achieved by a combination of slots and drilled holes. Once the manipulator jaws have been positioned from a general directional point of view by means of rotation of the outer handle and then from a rough open or closed point of view by the inward or outward movement of the special central pin, fine adjustment of the jaws can be achieved and a consequential grip exerted by rotation of the inner handle causing a slow axial movement of the central pin and hence fine adjustment.

Testing

All pressure sensitive parts of the ADS must be Proof-tested examined and certified prior to their use and are to be clearly marked with an identification number. Details of the Proof tests and identification numbers will be recorded in a special test log.

Cast and welded components will normally be subjected to one or more suitable NDT methods, as specified by Lloyds and the results recorded in the Test Log.

The following list sets out the Hydraulic Proof Test which should be applied to various components (N.B. reference to operating depth in salt water at a salinity of 35 parts per thousand and within the temperature range -2^{o} to $+32^{o}C$ and ignoring any compressibility effects.):

(A) Body - including dome, fitted view ports, all hull penetrations, O_2 bottles and piping and with all limb apertures blanked off.	1.15 X max, operating depth
(B) Boots and knee spaces	1.15 X max operating depth
(C) Limbs and joints - apart from the requirement to check for structural integrity, all joints must be checked at the proof depth.	1.15 X max. operating depth
(D) Manipulators - complete manipulator assemblies attached to the hand enclosure shall be tested for structural integrity as well as complete freedom of operation.	1.15 X max operating depth

(E) O_2 bottles - these shall be inspected and tested to a working pressure annually and proof-tested hydraulically with an internal examination at 4 yearly intervals.

(F) Wire rope and Terminal Connections-The combined Lifting/Communications Cable and Terminal Connection shall have a breaking load of not less than four times the maximum in Air Weight of the ADS plus weight of the rope.

(G) Pressure Relief Valve - the pressure relief valve is tested for satisfactory operation and must operate at a pressure of 1 psi or less.

(H) Pinger -A Helle model 2250 (27 khz) pinger is attached to the ADS so that it can be located by a diver held locator in an emergency. The pinger is fitted with a hydrostatic pressure switch which is designed to operate automatically over a depth range of 20 to 80 feet. The pinger switches off at depths greater than 80 feet. It is mounted on to the rear ballast weight

plate above the battery power pack and is held in position by two terry spring clips. A spring loaded hook is connected by means of a short lanyard to the ADS body. This hook is in turn connected to the pinger so that, in the event that the rear ballast weight is jettisoned, the pinger will be pulled out of the terry clips and remained attached to the ADS, suspended from the lanyard and spring loaded hook.

(I) Beacon - this is a Umel manufactured flashing beacon complete with four (4) mallory MM1500 1 1/2 volt batteries. The beacon is operated by means of a switch at its bottom end and is designed to withstand any pressure to which the ADS may be subject to.

Ballast System

Ballast Weight Release Systems

Ballast Weight Plates are fitted at the front and rear of the ADS Body.

The front Ballast Weight Plate is located by means of two-U-slots, the Rear Ballast Weight is located by means of a U-slot and 2 notches. The U-slots (or notches) located on to cam shafts at the bottom and fixed pins at the top. The cam shafts are operated by means of a lever inside the suit and sealed by means of O seals which bear against an aluminum bush set into the ADS body. One of these break-through plugs is also fitted with a female Oceanics plug (which is used to transform power from the Battery Pack to the inside of the suit).

Jettisoning and Emergency Surfacing System

Cable Jettison System

The combined Lifting and Communications cable is connected to the ADS at all times when the ADS is being operated. Under certain emergency conditions it may be necessary for the ADS operator to release the cable from the ADS and this is achieved by means of a special Cable Jettison System.

The cable terminates in the Cable Termination Adaptor which is normally pinned to the lifering body, which in turn is connected to a break-through plug via a square section threaded shaft. A handle on the inside of the ADS body can be operated by the ADS operator and four complete revolution of the handle in a counter-clockwise direction will cause the lifting body to unscrew from the square section threaded shaft, thus releasing the lifting cable.

Normal and Emergency Life Support System

Life Support System

The Life Support System consists of two independent completely interchangeable units, each containing a 500 litre capacity medical oxygen cylinder with maximum working pressure of 3200 psi. (220 bars) from these cylinders the oxygen is fed into the suit by continuous piping directly to a high pressure shut-off and regulating/reducing valve assembly. The oxygen at 4-6 atmospheres is then fed to the low pressure automatic controller which maintains the atmosphere within the suit at constant one atmosphere pressure by metering the oxygen input. The Operator wears an oro-nasal mask and exhales directly into the suit through a canister containing 5 lbs. of sodalime absorbant for scrubbing out Carbon Dioxide. As an extra precaution an additional canister containing 1 lb. of sodalime absorbant is located on the inhale side. Partial pressure of oxygen, suit internal pressure and temperature and high and low pressure oxygen supplies are constantly monitored by the Operator and recorded in the surface Log Book at regular intervals.

Emergency Life Support System

If the port system is in use and the port HPO_2 gauge drops to 30 bars this system will be isolated by closing the port O_2 high pressure valve and opening the starboard HPO_2 valve and the system checked for correct operation by observing the LPO_2 gauge and PO_2 monitor. By adapting this procedure there will be a reserve O_2 supply in the port bottle should the starboard system fail to operate.

Total duration of the two O_2 bottles is about 20 hrs.

Communications System

Communications Panel - Panel

Hard-line and Thro'Water communications Systems are provided.

The principal system is the Hard Line Communications System and the Thro'Water System is normally used only in an emergency.

The communications systems is arranged so that the ADS Operator can at all times be heard on the surface. The surface equipment is therefore normally set in an automatic receiving mode and the ADS Surface Controller has a "press to talk" switch in order to speak to the ADS Operator.

The ADS Operator normally speaks into a microphone which is fitted into his oro-nasal masks but he may in an emergency, speak direct into the transmitter unit in the Communications Panel by removing his mask, (To prevent excess of CO_2 build up, the mask should only be removed while actually talking)

Switches on the Communications Panel are arranged so that the Hard-Line Communications System is always switched on.

If the Cable jettison system is released then the Hard-Line Communications System will be inoperable. To change to the Thro'Water System the ADS operator must switch to the Thro'Water Communications System ON and adjust the Volume Control, and if no signal is received, switch to high power.

If the Battery fails or is released from the ADS, then the Thro'Water Communications System will be inoperable.

In an emergency situation, communication by means of the Hard Line System will cease when the ADS Operator releases the combined Communications/Life Cable. Thro'Water Communication will continue until the ADS Operator releases the Rear Ballast Weight and consequently the Battery Pack.

Communications System

This is howevery unlikely, becuase in practice he would normally only have to release the Front Ballast Weight and this in itself should be more than sufficient to allow the ADS to make a free ascent to the surface, thus allowing the ADS Operator and the Surface Controller to maintain contact throught the Thro'-Water Communications System.

Monitoring Devices for Depth

A Depth-sensor Break-through is fitted and is similar to the O_2 break-throughs, except that the Stainless Steel Pipe leading from the Break-through to the Depth Guage on the Port side of the ADS Body inside the suit, is connected to the Break-Through by means of an Ermeto Olive and Nut on the inside of the suit. Ambient pressure water is fed to the depth Gauge via a Choke (normally having a 15 thou diameter hole) which is fitted to the outside of the Break-through by means of a Nut.

Floatation And Bouyancy System

The normal negative bouyancy of the ADS on the bottom is usually 55 to 60 lbs, and can be changed to positive bouyancy by dropping all 100-150 lbs. of lead ballast on the suit by operation of 2 internal levers. These levers are located one in the front and one in the rear of the ADS at the operators belt level. Once released the ADS should then rise to the surface at approximately 100 feet per minute and float on the surface in an upright manner.

Handling System Components

A 1 ton crane or other suitable lifting equipment must be provided at the operation site for installation of the ADS and other backup equipment and must be able to cover the area of the deck of a ship or platform which is required by the ADS surface controller.

A 1 ton derrick or crane will also be required so that the ADS can be deployed and recovered safely from the working area of the deck or platform of the vessel or structure through the air/water interface. This derrick or crane must be capable of being operated over a reasonable radius so that the ADS can be lifted out of its stand and over the side of the vessel or structure at a sufficient distance away fron any hazards and without endangering the ADS operator or other personnel.

Proof test for the derricks or cranes shall be
____________________ 1.25 x swl

Proof test for other items shall be
____________________ 2 x swl

All items shall be examined and tested annually by a competent person and in accordance to NAVFAC/NAVSHIPS Instruction 11200.32A and a certificate issued.

Electrical System

The ADS is fitted with a pressure resistant battery pack which is used to power the Thro'-Water communications system as well as the internal light. The battery pack is located on the rear ballast weight plate, secured by two jubilee clips. Internal lights and Thro'-Water communications will continue until the ADS operator releases the rear ballast weight and consequently the battery pack. The battery pack is madeup of twelve individual two volt rechargeable cells connected to Oceanics Series 59 underwater female bulkhead connector. The connector is mounted on the end plate of the pack and connected to the suit by a flying lead to a similar Oceanics plug. The battery pack has a life of approximately 60 ampere hours. Batteries should be charged twice a week depending on how much the internal light and the Thro'-Water communication system is being used.

Accessibility to Vital Equipments

Once inside the ADS the operator can reach, read and operate all internal valves, gauges, light and CO_2 canister change over valve. This can be done with a minimum effort on the operator's part.

1. Port and starboard HPO_2 gauges
2. Port and starboard HPO_2 valves (OX 3, OX 4)
3. Port and starboard canister change over valve
4. Port and starboard bypass valve
5. Front and rear lead ballast release handles
6. Water depth gauge
7. PO_2 gauge
8. Internal light
9. Cable jettison handle
10. Thro'-Water Communications system switch
11. Dome closure handle
12. Beacon switch
13. Internal Pressure gauge (ie altemeter)

Predive Checkoff Procedures

For Use With The ADS #4

Submitted BY: Date:____________

Approved:______________________ Date:____________
Diving Officer

This procedure details the predive checkoff certificate for ADS maintenance personnel, operators, and ADS surface controller.

<u>No Diving will commence without the following number of personnel</u>

A) 2 ADS operator (1 standby ADS for dives deeper than present USN operational limits)

B) 1 telephone operator/ADS supervisor recorder

C) 1 crane operator

D) 2 ADS handling personnel

E) Standby diver (standby ADS operator)

F) Standby boat and crew for all open sea diving

Predive Procedures for ADS Technicians and Operators

Check the Following

Item	Note	Checkoff Port	Checkoff Starboard
CO_2 scrubbers	Charged and system correctly fitted		
O_2 cyliners	Charged to no less than 1600 PSI system correctly fitted, controllers set, pressure recorded.		
	HPO_2		
	LPO_2		

Life Support Lineup for ADS #4

Port side lineup

Gauge Number	Valve Number	Operation Checkoff	Initial
HPO_2-1	OX-1	OPEN	
HPO_2-2	OX-2	OPEN	
LPO_2-3	OX-3	OPEN	
LPO_2-4	OX-4	CLOSED	

Both bellows control tilt valves located below O_2 controller will be adjusted by turning the bellows adjusting knob clockwise unitl you hear O_2 escaping then backoff until O_2 stops escaping.

Note: Do not dive ADS unless both bottles contain 110 bars (1600 psi) or more. ADS valve #4 should be open to check bottle pressure and set bellows valve then closed for portside operational mode. To bleed down oxygen system close valve 1 and 2 above and open 3 and 4 bleed off both systems through bypass button located on top of port and starboard bellows control tilt valve.

Emergency Life Support System Lineup

Gauge Number	Cannister	Valve Number	Operation Checkoff	Initial
Port:				
HPO_2-1	ADS-1 (change	OX-1	OPEN	______
LPO_2-3	over valve	OX-2	OPEN	______
	down)	OX-3	OPEN	______
		OX-4	CLOSED	______
Starboard :				
HPO_2-2	ADS-2 (change	OX-1	OPEN	______
HPO_2-4	over valve up)	OX-2	OPEN	______
		OX-3	CLOSED	______
		OX-4	OPEN	______

Note: The ADS is fitted with two oxygen makeup bottles each of 500 liters capacity and with a total duration of the two bottles of about 20 hours. When the port HPO_2 drops to 30 bars this system would be isolated by closing the port O_2 high pressure valve and opening the starboard high pressure valve and the system checked for correct operation and observing the LPO_2 monitor. By adapting this procedure there will be a reserve O_2 supply in the port bottle should the starboard system fail to operate. Dives planned to last more than 1 hour will begin with fresh CO_2 absorbant in all canisters. At no time will one absorbant change be used for longer than 2 hours.

CAUTION: Observe all safety precautions for working around HPO_2 systems.

Predive Procedures for ADS Technicians and Operators

Check the Following

ITEMS	NOTE	CHECKOFF PORT	CHECKOFF STARBOARD
Manipulators	Required manipulators fitted and checked for correct operations	______	______
CO_2 change over valve gauges	Clean, dry and operates easily, fitted and checked temperature, cabin pressure depth	______	______
Limbs	Check that all items are correct, "O" seals fitted and that all joints are fully topped up with fluid and free to move	______	______
Cable Jettison System	Communications and lifting cable correctly fitted, release handle operates easily	____________	
Front ballast system	Mechanism operates satisfactorily and locked front ballast weight fitted	____________	
Check Weight Log	(Weight lbs.)	____________	
Rear Ballast System	Mechanism operates satisfactorily and locked rearballast weight fitted.	____________	
Check Weight Log	(Weight lbs.)	____________	
Hard Line Telephone	Check and operating satisfactorily	____________	

Predive Procedures for ADS Technicians and Operators

ITEM	NOTE	CHECKOFF
Thro'Water Communications:	Transducer correctly fitted	
	Internal connections correct	
	Battery pack charged and plug fitted	
	Silicone greased	
	Voice check satisfactory	
Internal light	Functioning satisfactorily	
Parts	Clean, dry, correctly fitted	
Hatch seals	Surfaces cleaned and operating system satisfactorily	
Suit interior	Clean and dry	
External surface of suit	Free from defects	
Flashing beacon	Correctly fitted, working and secured	
Lifting derrick	Visually checked for safe working load	

Predive Procedures for ADS Technicians and Operators

ITEM	CHECKOFF
Pen light for emergency use	______
O_2 controller operating satisfactory	______
Back pack fitted and secured	______
Dreager PO_2 monitor ON (battery) Stabilized at 21% O_2 (160 MMHG)	______
Unused battery in B	______
Emergency lifting shackle O.K.	______
Face mask, valves, tubes, fittings, couplings correctly fitted. Mask wiped out with alcohol after last dive. Check canister hoses for kinks.	______
Cabin pressure gauge adjusted to read zero.	______
Do not plug battery in until internal systems are plugged in	______

I hereby certify that the items on this checklist have been properly completed.

SIGNATURE: ______

DATE: ______

TIME: ______

Predive Procedures for ADS

Surface Controller/Supervisor

ITEM	NOTE	CHECKOFF
ADS Operator	Adequately briefed, suitably equipped and understand tasks	________
Predive procedure	Signed by ADS technician and ADS operator	________
Back-up personnel	Briefed regarding duties and in position: communications deck handling crew winch swimmer emergency recovery personnel	________
Area	Safe and free of hazards	________
Clearance	Obtained from diving officer and/or captain	________
Tracking equipment	Available	________
Emergency	Recovery method to be used	________

I hereby certify that the items on this checklist have been properly completed and permission has therefore been granted for the dive to take place.

SIGNATURE: ________

TIME: ________

DATE: ________

AD-A112 879 NAVAL MEDICAL RESEARCH INST BETHESDA MD F/G 6/19
A BIOMEDICAL ASSESSMENT OF A ONE-ATMOSPHERE DIVING SYSTEM: JIM---ETC(U)
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UNCLASSIFIED NMRI-81-70 NL

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Post Dive Procedures

For Use With ADS #4

Submitted by: Date:____________

Approved: ______________________ Date:____________
Diving Officer

This procedure details post dive maintenance.

Post Dive Procedure

Upon the completion of the diving day the following procedures will be taken:

1. Secure O_2 system and recharge bottles for next day. When securing O_2 system secure oxygen valves 1 and 2 open oxygen valves 3 and 4, bleed off both systems through by pass button located on top of port and starboard bellows control tilt valve.
2. Remove CO_2 canisters and empty. Do not refill until the next morning.
3. Wipe down insides of ADS and blow down with air to aid drying process.
4. Wipe down external parts of ADS with dry cloth.
5. Spray halo carbon oil on leg joints and exposed metal parts.
6. Put battery on charge if needed.
7. Block up each leg to keep air from entering the joints.
8. Secure ADS to stand, leave crane attached to lifting shackle.
9. Use halo carbon grease on "0" ring seals whenever needed.
10. When diving in salt water, wash ADS down with fresh water.
11. Remove mask, wipe down with alcohol and blow hoses dry with air.
12. Tie arms up in a raised position.

Caution: Observe all safety precautions for working around HPO_2 systems.

Ser 11491

Maintenance Procedures

For Use With ADS

Submitted BY: DATE:________________

Approved: ____________________ DATE:________________
Diving Officer

This procedure details post operation and yearly maintenance.

ADS Maintenance Procedures

Item	Post Operation (workshop)	YEARLY
Series II and III joints Not to be stripped on site will be sent back to workshop.	Joints should be stripped right down, all parts thoroughly cleaned and examined. All "O" seals should be replaced with new ones and the joints should be fitted with new fluid.	SAME
Connecting Limb Assemblies Series II joints Not to be stripped on site will be sent back to workshop.	Limbs are stripped down to individual parts which are thoroughly cleaned and inspected. All "O" seals will be replaced with new ones prior to reassembly.	SAME
Battery Power Pack	The Battery Power Pack should be removed from the rear ballast weight plate, stripped down and individual cells examined for signs of leakage or defective wires. Before assembly "O" seals should be replaced. The battery should be recharged before it is fitted back on to the ADS.	SAME
Pinger	Check the condition of the batteries and replace if necessary.	SAME

ADS Maintenance Procedures

ITEM	Post Operation (workshop)	YEARLY
Communication Panel Suit	All Parts should be thoroughly examined and electrical connections ckecked and repaired and replaced if necessary.	SAME
Beacon	The Battery should be replaced with a new one and a new bulb fitted.	SAME
ADS Body and Dome	The surface of the ADS body, dome boots, legs, knees, spacers and arm enclosures should be thoroughly cleaned and examined and serious defects should be noted and repairs carried out.	SAME

ADS Maintenance Procedures

ITEM	Post Operation (workshop)	Yearly
Dome Closure System	The two "0" seals should be scraped and the grooves thoroughly cleaned and two new "0" seals carefully fitted. The mating surface on the dome and the body should be thoroughly examined. The port and the starboard dome closure system should be stripped down, cleaned, examined and new "0" seals fitted before reassembly. The two systems should be checked in particular for correct operation of the cams against the stainless steel pins.	SAME In addition the dome hinge pin assembly should be stripped down thoroughly, cleaned and examined.
Joint Adapter Rings	Stripped down to individual parts which are thoroughly cleaned and inspected. All "0" seals will be replaced by new ones prior to assembly.	The joint adaptor rings should be removed along with the polycast between the rings and the ADS body. The mating surfaces and helicoil inserts should be thoroughly examined for signs of corrosion and all parts thoroughly cleaned prior to re-assembly.

ADS Maintenance Procedures

ITEM	Post Operation (workshop)	YEARLY
Auxiliary Lifting Attachment	Removed from ADS body stripped down thoroughly cleaned, examined and a new "O" seal fitted before reassembly.	SAME In addition, a record should be made in the register containing details of examination and certification of all lifting equipments, that the attachment has been examined and found fit for future use.
Lifting Equipment	As for each dive. In addition the complete lifting cable should be thoroughly examined throughout its length by a competent person. All running gear should be stripped down, thoroughly cleaned and examined and greased prior to reassembly.	SAME In addition, items of all lifting gear will be cleaned and thoroughly examined, a competent person certificates issued.

ADS Maintenance Procedures

ITEM	Post Operation (workshop)	YEARLY
Ballast Weight Release Systems	Strip down the cam shaft assemblies of the front and rear systems, clean and thoroughly examine and fit "O" seals before reassembly. Check that each catch-plate is securely fitted to the ADS body and that the trigger and associated spring operate correctly. Strip down, clean and thoroughly examine the two break-throughs on the rear of the suit which act as location points for the rear ballast weight place and replace "O" seal before reassembly.	SAME In addition the fixed pin which is screwed to the ADS body and serves to locate the front weight plate should be removed. (along with the helicoil insert) and examined any defects or signs of corrosion.
Transducer Housing	The housing should be removed from the ADS body and carefully cleaned. The mating surfaces of the transducer housing and ADS body and the helicoil inserts should be carefully examined for signs of corrosions and a new "O" seal should be refitted before assembly.	SAME
Static Break-throughs	Disconnect the break-throughs, strip down, thoroughly clean and examine and replace "O" seals before reassembly.	SAME In addition the spring in the pressure relief valve should be replaced by a new one.

ADS Maintenance Procedures

Cable Jettison System	The system should be stripped down, thoroughly cleaned and examined and all "0" seals replaced before reassembly. If there are any signs of damage to the Thrust Washers these should be replaced.	SAME In addition the electrical terminal unit should be removed and replaced and the main Bush removed from the ADS body and thoroughly cleaned and inspected before being replaced with all other items.
Viewports	Remove Port Retaining Rings and ports and thoroughly clean and examine. "0" seals should be replaced with new ones before reassembly.	SAME
Manipulators	The manipulators should be stripped down thoroughly cleaned and examined and all "0" seals and Thrust Washers replaced before reassembly.	SAME
Life Support System	Strip down, thoroughly clean and examine all parts of Life Support System and replace all "0" Seals before reassembly.	SAME In addition it will be noted that the O_2 cylinders are subject to an annual proof-test and examination by an independent authority and arrangements will be made accordingly.

Cable and Jettison System Procedures

For Use With ADS #4

Submitted BY: DATE:______________

Approved:_________________________ DATE:______________
Diving Officer

This procedures details cable jettison system.

Cable Jettison System

Handle	Operation Checkoff
Top Center of ADS body	Release (see note)

Note: The combined lifting and communications cable is connected to the ADS at all times when the ADS is being operated. Under certain emergency conditions it may be necessary for the ADS operator to release the cable from the ADS and this is achieved by means of special cable Jettison system. The cable is attached to the termination adaptor located on top of the ADS. The adaptor is connected to a break-through plug via a square section threaded shaft. A handle on the top inside of the ADS body can be operated by the ADS operator by turning it four complete revolutions counterclockwise. This will cause the lifting body to unscrew from the square section threaded shaft and releasing the lifting cable. The operator will only jettison the lifting cable as the last resort.

Life Support System Operational Check Out Procedures

For Use With The ADS #4

Submitted BY: DATE:_______________

Approved:______________________ DATE:_______________
Diving Officer

This procedure details the line-up of the oxygen system, CO_2 scrubbing system.

Operational Lineup of the Life Support System for ADS

This lineup shows utilization of the port and starboard life support systesm.

CO_2 canisters can be shifted from port to starboard by shifting the changeover valve to the up position. The change over valve is located where the oral-nasal mask connects to the life support system.

Life Support Unit

Valve Number	Cannister	Operation Checkoff
Port		
OX-3	ADS-1	OPEN
OX-4	ADS-2	CLOSED
Starboard		
OX-3	ADS-1	CLOSED
OX-4	ADS-2	OPEN

NOTE: When the port HPO_2 drops to 30 Bars this system will be isolated by closing the port high pressure valve ADS-3 and opening the starboard high pressure valve and the system checked for correct operation (by observing the LPO_2 gauge and PO_2 monitor). This procedure allows a reserve O_2 supply in the port O_2 bottle should the starboard system fail to operate.

A. D. S. Oxygen Line-up

Gauge Number	Valve Number	Operation Checkoff
OX-1	OX-1	OPEN
OX-2	OX-2	OPEN
	OX-3	OPEN
	OX-4	CLOSED

Note: Do not dive ADS unless both bottles contain 110 bars (1600 psi) or more. ADS valve #4 should be open to check bottle pressure then close for portside operational mode. See note on proceeding page.

Both bellows control tilt valves located below O_2 controller will be adjusted by turning the bellows adjusting knob clockwise until you hear O_2 escaping then backoff until O_2 stops escaping.

Caution: Observe all safety precautions for working around HPO_2 systems.

Securing the Life Support System

To secure the life support system, the following procedures are:

Valve Number	Canister Number	Operation
OX-3	ADS-1	CLOSED
OX-4	ADS-2	CLOSED
OX-2		CLOSED
OX-1		CLOSED

Caution: Observe all safety precautions for working around HPO_2 systems.

Ballast System Operational Procedures

For Use with ADS #4

Submitted BY: DATE:____________

Approved:____________________ DATE:____________
Diving Officer

This procedures details Ballast System Operational Mode.

Operational Lineup For Ballast System

Handle	Operation Checkoff
Front	Locked Vertical Position
Rear	Locked Vertical Position

Note: Ballast weight plates are fitted at the front and rear of the ADS body. The front ballast weight plate is located by means of two U-slots. The rear ballast weight is located by means of a U-slot and two notches. The U-slots (or notches) are located on cam shafts at the bottom and fixed pins at the top. The normal negative bouyancy of the ADS on the bottom is usually 55 to 60 lbs. and can be changed to positive bouyancy by dropping all 100-150 lbs. of lead ballast. This is accomplished by throwing the two internal levers in the down position. The levers are located one in the front and one in the rear of the ADS at the operator's belt level. Once released the ADS should rise to the surface at approximately 100 ft. per minute and floats on the surface in an upright manner. The operator will only jettison his Ballast Weights as the last resort in an emergency.

Internal Systems Readings Procedures

For Use With ADS #4

Submitted BY: DATE:____________

Approved:__________________ DATE:____________
Diving Officer

This procedure details how often to take internal readings and log chart.

Internal Systems Readings

From the time that the hatch is closed the performance of the operator will be monitored and checks made on all gauges to ensure that his life support system is functioning correctly.

Upon reaching the bottom and at intervals of no more than 15 minutes, gauge measurements will be taken and recorded on the log chart. Readings will be taken more often if operator is working extremely hard. The operator will at all times keep a close check on his internal system gauges and notify topside if any of the following readings exist:

1. The internal pressure gauge goes into the red.
2. The O_2 sensor reads 18%.
3. The O_2 sensor reads 25% or more.
4. One system reads 30 bars on HPO_2 gauges.

Should the Internal Pressure Gauge (altimeter) go in to the red this could be a sign of low O_2 pressure. Check your PO_2 sensor if the reading is low this can be brought up by pressing the bypass valve button located on the top of the O_2 controller bellows of the system in use. Should the Internal Pressure Gauge (altimeter) go to the left your CO_2 absorbant may not be working check your PO_2 sensor and shift to opposite canister by swinging the canister valve in the other direction. Any occurences which might affect the safety of the operator will also be noted.

See abort procedures for additional information.

PORT STARBOARD

PO_2	HPO_2	LPO_2	TEMP.	TIME	INT. PRE.	DEPTH	PO_2	HPO_2	LPO_2

Procedures for Electrical System

For Use With ADS #4

Submitted BY: DATE:______________

Approved:____________________ DATE:______________
Diving Officer

This procedure details electrical system operation.

Electrical System Procedures

Plug	Operation Checkoff
Oceanic Breakaway Right or Center Rear.	Plugged and Greased
Internal Light	Burning

Note: The ADS is fitted with a pressure resistant battery pack which is used to power the Thro'Water communications system as well as the internal light. The battery pack is located on the rear ballast weight plate, secured by two jubilee clips. Internal lights and Thro'Water communications will continue until the ADS operator releases the rear ballast weight and consequently the battery pack. The battery pack is made up of twelve individual two volt re-chargeable cells connected to Oceanics Series 59 underwater female bulkhead connector. The connector is mounted on the end plate of the pack and connected to the suit by a flying lead to a similar Oceanics plug. The battery pack has a life of approximately 60 ampere hours. Batteries should be charged twice a week depending on how much the internal light and the Thro'Water communication system is being used.

Emergency Life Support Procedures

For Use With The ADS #4

Submitted BY: DATE:______________

Approved:____________________ DATE:______________
Diving Officer

This procedure details the lineup for emergency life support.

Emergency Life Support Lineup

Gauge Number	Cannister	Valve Number	Operation Checkoff
Port:			
HPO_2-1	ADS-1	OX-1	OPEN
HPO_2-2		OX-2	OPEN
LPO_2-3		OX-3	OPEN
LPO_2-4		OX-4	CLOSED
Starboard:			
HPO_2-1	ADS-2	OX-1	OPEN
HPO_2-2		OX-2	OPEN
LPO_2-3		OX-3	CLOSED
LPO_2-4		OX-4	OPEN

Note: The ADS is fitted with two oxygen make up bottles each of 500 liters capacity and with a total duration of the two bottles of about 20 hours. When the port HPO_2 drops to 30 bars this system would be isolated by closing the port O_2 high pressure valve and opening the starboard high pressure valve and the system checked for correct operation by observing the LPO_2 gauge and PO_2 monitor. By adapting this procedure there will be a reserve O_2 supply in the port bottle should the starboard system fail to operate.

Caution: Observe all safety precautions for working around HPO_2 systems.

Emergency Ascent Procedures

For Use With ADS #4

Submitted BY: DATE:______________

Approved:______________________ DATE:______________
Diving Officer

This procedures details Emergency Ascent Methods.

Emergency Ascent Procedures

During an emergency situation the surface tenders should be alert and prepared for the operator to make a free ascent. All slack will be taken out of the lifting and communication cable.

If the ADS is caught on the bottom, the diving supervisor will take immediate steps to deploy a second ADS or conventional diving system or submersible depending upon which system is being used for standby. The diving supervisor will keep constant communication with the ADS operator advising him of the steps which are being taken to effect his recovery.

Should there be a complete breakdown in communications the operator must assume that steps are being taken to effect his recovery and must not jettison his ballast weights until he determines that his life is in immediate danger. In this circumstance, the operator will first release the lifting and communications cable. This is accomplished by turning a handle on the top inside of the ADS body four revolutions counterclockwise.

The last step for the operator is to release his ballast weights. This is accomplished by throwing the two internal levers in the down position located in the front and one in the rear of the ADS at the operators belt level. Once released the ADS should rise to the surface at approximately 100 feet per minute.

During ascent communication with the operator via the Thro'Water system will be maintained. Once on the surface the operator will not open the dome hatch until recovery is made.

The diving supervisor will deploy the surface swimmer to hook up the emergency lifting line to the shackle located on the right rear top of the ADS.

Loss of Communications Procedures

For Use With ADS #4

Submitted BY: DATE:______________

Approved:______________________ DATE:______________
Diving Officer

This procedure details technique to be used when communications fail.

Loss of Communications Procedures

If there is a loss of communications the following procedures will be strictly followed:

1) The ADS is normally fitted with two completely separate communication system:

   (A) The hard line system
   (B) The Thro'Water system

2) Where both systems are fitted they should both be capable of operation and if during an actual dive there is a complete failure of either system then the mission will be aborted.

3) In the event of a failure to the hard line communication system the operator and diving supervisor will carryout checks lasting no more than three minutes with a view to establishing contact.

4) If these checks do not result in a reconnection of the system then both the ADS operator and diving supervisor will switch to the Thro'Water system. It is highly unlikely that this system will have failed as well but if it has and if communication cannot be established then checks should be made for one way communication.

5) There are a number of ways to check for one way communication.

   (A) ADS operator asking diving supervisor to flash underwater lights if in use.
   (B) Diving supervisor asking ADS operator to position himself in front of a t.v. camera and make certain gestures or signs against negative or positive question.
   (C) Once it has been established that one way communication exists then limited communication on a yes/no basis may be established.
   (D) If it is determined that no communications exist either way and if a t.v. system is available then the ADS operator should indicate that "all is well" by raising and lowering of the right armor rotation of the right manipulator.

6) This technique will be used with a view to recovering the ADS as quickly as possible after determining that there are no complications other than the communications failure.

Loss of Communications Procedures

7) The ADS operator will check to make sure that the ADS is not snagged in anyway and that a normal ascent can be made.

8) After allowing the ADS operator time to move to a safe and unobstructed area the diving supervisor will commence normal recovery operations. Deploying the standby diver or emergency swimmer if necessary to establish visual contact with the ADS.

Abort Procedures

For Use With ADS #4

Submitted BY; DATE: ______________

Approved: ______________________ DATE: ______________
Diving Officer

This Procedure details the abort Procedures.

ADS Abort Procedures

These procedures are set down by way of General Guidance and should be followed whenever possible. Overall responsiblity for the ADS during an operation rest with the Diving Supervisor. He may use his discretion to modify procedures used in an emergency depending on the circumstances of a particular situation and having due regard to the safety of personnel and equipment.

Abort Procedures

(A) The ADS is normally fitted with two completely separate communication systems.

a) The hard line system
b) The Thro'Water system

When both systems are fitted they should both be capable of operation if during an actual dive there is a complete failure of either system then the mission will be aborted.

(B) If structural damage is caused to the ADS suit or if leakage occurs , then the ADS operator will notify the diving supervisor and the operation will be aborted as quickly and safely as possible.

(C) Should one of the life support systems fail then the operation will be aborted.

(D) If a high level of CO_2 exists (.5% or more) then the operation will be aborted.

(E) If a high level of O_2 exists (25% or more) then the operation will be aborted.

(F) If a low level of O_2 exists (18% or less) then the operation will be aborted.

APPENDIX C

FORMS USED IN STUDY

RECORDABLE EVIDENCE ITEMS LISTED BELOW ARE REQUIRED FOR DIVES TO DEPTHS GREATER THAN 100 FEET AND WILL BE REQUIRED IN A SEPARATE PSOB FOR ADS JIM #4.

Page #	Item #	SUBJECT
		(PRESSURE HULL)
1	2	Calculations for Collapse Pressure and Stress Levels
1	5	Review of As Built Fabrication Drawings for Conformance to Design Parameters and Calculations
		(FABRICATION)
1	7	Material Traceability a. Inspection requirement of base material Remarks: Identification required for GRP and aluminum insert of arm enclosures.
2	8	Scantling dimensions 1. Shell thickness, frame sizes, location of penetrations.
2	9	Proof Test
2	11	Material Survey of Submersible - Check as built drawings against actual fabrication. Review any or all of the above.
		(APPURTENANGES)
4	C-1	Windows a. Procedures for window design b. Calculations for Collapse Pressure and Stress Levels.
5	e	Review of As Built Fabrication Drawings for Conformance To Design Parameters and Calculations
5	g	Material Traceability
5	i	Proof Test
5	k	Material Survey of View Ports - Check as built drawings against actual fabrication. Review any or all of the above.
		(HATCHES)
5	2-b	Calculations for Collapse Pressure and Stress Levels
5	2-e	Review Of As Built Fabrication Drawings for Conformance To Design Parameters and Calculations.
6	i	Proof Test
6	k	Material Survey of Submersible - Check as built drawings against actual fabrication. Review any or all of the above.
		(INSERTS AND PENETRATORS, ELECTRICAL PIPING)
6	3	(1) Description (e.g. MIL.SPEC. or Purchase Spec.) (2) Material Justification (When applicable) Remarks: Equivalent specification and compatibility with Castrol is required for "o" rings used in ADS per NAVSEC LTR 6129/JJS 9110 Ser 42 of

Page #	Item #	SUBJECT
		(INSERTS AND ELECTRICAL PIPING)
6	3-e	Review of As Built Fabrication Drawings For Conformance To Design Parameters and Calculations
7	g	Material Identification
7	j	Insert Surveillance Survey
7	k	Material Survey of Submersible - Check as built drawings against actual fabrication. Review any or all of the above.
		(LIFTING AND COMMUNICATIONS CABLE JETTISON DEVICE)
10	3	Material Evaluation a. Description of material used (e.g. MIL.SPEC., ASA, commercial, etc.)
10	4	Review Working Drawings (e.g. Assembly and detail plans; plans of components such as solenoid operated mechanisms)
10	8	Material Identification (e.g. Receipt Inspection)
10	9	Strength and Tightness Test (e.g. Bench test, Leak test, Hydro test)
		(LIFE SUPPORT SYSTEMS) (OXYGEN SYSTEMS)
11	3	a. Description of Material or component (e.g. MIL. SPEC.)
11	12	Material Survey of Submersible - Check as built drawings against actual fabrication.
		(CARBON DIOXIDE REMOVAL SYSTEM)
12	3	a. Description of Material or Component (e.g. MIL. SPEC.) b. Material or Component Justification
12	4	Review Working Drawings - Including description of material, fittings, valves, gages, etc.
12	6	Review System Fabrication Procedures (e.g. Weld preparation, welder qualification, mechanical joints, take down joints, ect.)
12	10	Material Survey of Submersible - Check as built drawings against actual fabrication.
		(CO2 MONITORING SYSTEM)
12	c	a. Description of Material or Component (e.g. MIL. SPEC.) b. Material or Component Justification Remarks: No CO2 analyzer - Information on adding this equipment is pending.
12	2	Review Working Drawings - Including description of material, fittings, valves, gages, etc.
13	7	Material Survey of Submersible - Check as built drawings against actual fabrication.

Page #	Item #	SUBJECT
		(TOXIC AND FLAMMABLE MATERIAL IDENTIFICATION)
16	1	Material Evaluation (categorize per Appendix A of Certification Manual NAVSHIPS 0900-028-2010)
16	3	Analysis of Vehicle's Atmosphere for trace contaminants (samples of atmosphere to be taken during and at end of a simulated closed boat operation with full complement of personnel and analyzed at an acceptable commercial laboratory)
16	4	Material Survey of Submersible Remarks: Review NAVSEA list against ADS internal materials - NMRI identify.
		(COMPONENTS WITH NON-CRITICAL IMPLODABLE VOLUMES)
18	A	a. Description of Component (including geometry and materials) b. Orientation of implodable item with respect to scope items c. Test depth and/or designed depth of implodable item Remarks: Applicable to Pinger Housing
18	2	Calculations of volume and minimum standoff distance Remarks: Per NAVMAT P-9290
		(COMPONENTS WITH CRITICAL IMPLODABLE VOLUMES)
18	B-a	Description of Component Remarks: Applicable to Battery Case
18	B-2	Prototype Tests (Category 3 Components) a. Static strength test (2times maximum operating depth) b. Fatigue test - Full anticipated life cycle times four c. Stress corrosion in sea water (run concurrently with fatigue test) d. Temperature and Tightness Test e. Strength Test Prototype Pressure Container to Collapse (in sea water) - Determine failure mode Remarks: Verify tests accomplished by British
18	3	Submergence Test (Category 1, 2 and 3 Components) Pressure Test to 1-1/2 times test depth for 10 cycles; 10 minutes at greatest pressure - cycles 1-9, 1 hour at greatest pressure - cycle 10, (35^{o} F sea water if practicable). Leakage or visible signs of external damage shall be cause for test failure. Remarks: Verify tests accomplished by British
		RELEASE DEVICES (FRONT AND REAR BALLAST WEIGHT)
19	3	a. Description of material used (e.g. MIL.SPEC., ASA, Commercial, etc.) b. Material Justification

Page #	Item#		Subject
19	4		Review Working Drawigns (e.g. Assembly and Detail Plans; Plans of components such as solenoid operated mechanisms)
19	8		Material Identification (e.g. Receipt Inspection, etc.)
			DEPTH DETECTORS (COMPONENTS EVALUATION)
24	1	a.	Descriptions of Dependent Depth Detecting Devices (e.g. Manufacturer's Brochures, Design Parameters, Mil. Spec., Comm. Spec., etc.)
24	1	b.	Material Identifications and Justification for the Operating Environment (e.g. Salt Water, Air, Oil, etc.)
			ELECTRICAL POWER SYSTEM (SUPPORTING DATA AND CALCULATIONS)
29	2	e.	Penetrator Qualification tests
		f.	Battery compensating valve differential pressure test
29	3	a.	Suitability of cable jacket conductor insulation material for specific application (e.g. compatibility with oils and temperature limitations)
		b.	Flammability, toxicity, water absorption, fungus resistant, characteristics of insulating materials (e.g. Terminal boards, mounting cards, tapes, etc.)
30	4	a.	Identification of materials and equipment as to applicable military spicification, commercial designation or manufacturer's number.
30	5	c.	Detail instructions for charging, servicing and determinign acceptable conditions of batteries.
30	6	a.	Pre-installation test and installation procedures
		b.	Penetrator hull attachment including sealing gasket seats.
30	7	a.	Insulation resistance to ground of all electrical cables and systems, at a 500 volt potential (switches to equipment open)
		b.	Insulation resistance between conductors in cables.

<u>OPERATOR</u>

PREDIVE CHECKOFF PROCEDURES FOR ADS #4

PURPOSE OF DIVE: ____________________

DURATION OF DIVE: ____________________

1. 0^2 BOTTLE VALVES OPEN PORT: ________ STARBOARD: ________

2. STARBOARD LIFE SUPPORT SYSTEM CHECKED SATISFACTORILY AND OXYGEN SHUT OFF VALVE IN SUIT CLOSED. Hi-PO^2 ________ Lo-PO^2 ________

3. PORT LIFE SUPPORT SYSTEM CHECKED SATISFACTORILY SYSTEM LEFT IN OPERATION Hi-PO^2 ________ Lo-PO^2 ________

4. FACE MASK, VALVES, TUBES, FITTINGS, COUPLINGS CORRECTLY FITTED AND OPERATING SATISFACTORILY. MASK WIPED OUT WITH ALCOHOL INHALE ________ EXHALE ________

5. DREAGER PO^2 MONITOR ON BATTERY A & STABILIZED AT .21% (160 MmHb) ________

6. CABIN PRESSURE GAUGE ADJUSTED TO READ ZERO ________

7. PEN LIGHT FOR EMERGENCY LIGHT ________

8. BACK PACK COVER FITTED AND SECURE ________

9. EMERGENCY LIFTING POINT SATISFACTORY ________

10. BALLAST JETTISON SYSTEMS FREE TO BE OPERATED FRONT WT:____ REAR WT:______

11. COMBINED COMMUNICATION AND LIFTING CABLE JETTISON SYSTEM FREE ________

12. COMMUNICATIONS SYSTEMS SATISFACTORY HARD LINE____ THRO' WATER(BATT TEST)____

13. THRO' WATER TRANSDUCER DEPLOYED ________

14. FLASHING BEACON ACTIVATED ________

15. DO NOT PLUG BATTERY IN UNTIL INTERNAL SYSTEMS ARE PLUGGED IN ________

16. ADS CLEAN AND DRY AND READY TO ENTER ________

17. HATCH CLEAN AND READY TO CLOSE AND OPERATOR READY TO DIVE. ________

Signature: ____________________

Date: ________ TIME: ________

COMMENTS:

(Over for Maintenance)

MAINTENANCE

PREDIVE CHECKOFF PROCEDURES FOR ADS #4

1. ALL "O" RING SEALS IN POSITION AND LIMBS CORRECTLY FITTED. ____
2. ALL JOINTS CORRECT AND FREE TO MOVE. ____
3. REQUIRED MANIPULATORS FITTED AND CHECKED. ____
4. CO^2 SCRUBBER CHARGED AND CORRECTLY FITTED PORT ____ STARBOARD ____
5. 0^2 CYLINDERS CHARGED AND VALVE OPEN PORT Hi-PO^2 ____ PORT Lo-PO^2 ____
   STARBOARD HiPO^2 ____ STARBOARD HiPO^2 ____
6. 0^2 CONTROLLERS OPERATING SATISFACTORILY PORT ____ STARBOARD ____
7. FRONT BALLAST WEIGHT FITTED & RELEASE MECHANISM FREE. LBS. WT. ____
8. REAR BALLAST WEIGHT FITTED & RELEASE MECHANISM FREE. LBS. WT. ____
9. BACK PACK FITTED AND SECURE. ____
10. FLASHING BEACON FITTED AND SECURE. ____
11. REAR BATTERY PACK CHARGED AND FITTED & PLUG GREASED. ____
12. COMMUNICATIONS/LIFTING CABLE CORRECTLY FITTED. ____
13. CABLE JETTISON SYSTEM SATISFACTORY. ____
14. PO^2 MONITOR FUNCTIONING SATISFACTORY. ____
15. UNUSED BATTERY IN "B" POSITION. ____
16. SUIT INTERIOR AND PORTS CLEAN AND DRY (BLOW DOWN AFTER EACH DIVE) ____
17. CO^2 CHANGE OVER VALVE CLEAN AND DRY AND OPERABLE. ____
18. THROUGH WATER COMMUNICATIONS SYSTEM CHECKED. ____

Signature: ____________________

Date: __________ Time: __________

COMMENTS:

(OVER FOR OPERATOR)

LIST O RINGS TO BS 1806

Life Support Controller		
Adjust Screw	006	2
O2 Bottle	013	2
Tilt Valve & Covser	012	2
Soda Lime Can	120	6
Body		
Dome Closure Outer	JW 17124	1
Dome Closure Inner	JW 17120	1
Dome Ports	50-267(5560)	4
Body Ports Outer	50-243(5580)	2
Body Ports Inner	50-247(5580)	2
Static Breakthrough	50-210(5580)	6
Rotary Breakthrough	50-016	2
Excess Pressure Valve	50-017	1
Dome Close Shaft	50-012	2
Hip Joint		
Filler Plug	50-010	2
Split Ring Inner	50-267	2
Cylinder Joint	50-272	2
Dowty Pistol Joint	50-379(4470)	2
Piston Stop	50-449	2
Piston Seal Inner	50-448-273-375	2
Piston Seal Outer	50-455-279-382	2
Knee Joint		
Filler Plug	50-010	2
Split Ring Inner	50-260	2
Dowty Cylinder Joint	50-369	2
Piston Joint	50-272	2
Piston Stop	50-445	2
*Piston Seal Inner	884 DOWTY-264	2
Piston Seal Outer	50-450-275	2
Shoulder Joint		
Filler Plug	50-010	2
Split Ring	50-260	2
Piston Stop	50-445	2
Piston Joint	50-271	2
Piston Seal Inner	4460-884 DOWTY-264	2
Piston Seal Outer	50-450-275	2
Cylinder Joint	50-449	2
Lower Arm		
Filler Plug	50-010	2
Split Ring	50-250	2
Piston Joint	50-264	2
Cylinder Joint	50-258	2
Piston Seal Inner	50-435-252	2)
Piston Stop	50-435	2)Same
Piston Seal Outer	50-445-266	2
Boot		
Joint leg spacer	370 DOWTY	2

Continued

Continued

<u>Cable Jet Assembly</u>			
	Body Bush/shaft	214	1
	Lower Bush/shaft	214	1
	Body Bush/body	239	1
	Lower Bush/body	030	1
	Terminal	111	1
<u>Manipulator</u>			
	Adaptor Ring/hand ecl J4/7	258	1
	Chassis/Adaptor	230	1
	Rotary Seal	118	1
	Shaft Seal	112	3
<u>APAPP</u>			
	Piston	255	1
	Piston	129	1
	PTFE Backup pins	129	1
	End cap	136	1
	Cylinder & tube	165	3
	Spool valve & plus	111	7

JIM-4 ADS
DIVE LOG SHEETS

DATE__________

DIVE LOCATION__________ DIVE PLATFORM __________

DIVE OFFICER __________ TENDERS __________

DIVER SUPERVISOR__________ STANDBY DIVER __________

OPERATOR __________ PHONES/LOG__________

TIME HATCH SHUT__________

TIME ENTERED WATER__________

TIME REACHED BOTTOM __________

TIME SURFACED __________

TIME HATCH OPENED __________

TOTAL TIME OF DIVE __________

WATER ENVIRONMENT

WATER DEPTH __________

VISIBILITY __________

WATER TEMP. __________

BOTTOM TYPE __________

HARD LINE COMMUNICATION CHECK __________

WATER LEAKAGE CHECK __________

PURPOSE OF DIVE __________

THROUGH WATER COMMUNICATIONS CHECK __________

____

____

JIM-4 ADS ENVIRONMENT(READINGS EVERY 20 MINUTES)

TIME									
02%									
PCO^2									
CAB PRESS									
LPO^2									
HPO^2									
TEMP									

Continued

SUIT PROBLEMS: ____

____

TASK PERFORMANCE COMMENTS AND OPERATOR DEBRIEFING: ____________

____

____

____

____

SIGNATURE: ______________________ SIGNATURE: ______________________

DIVE OFFICER DIVE SUPERVISOR

D.H.B. CONSTRUCTION LTD

Permission to Dive Certificate - ADS Surface Controller

ADS No. ______ ADS TYPE ______

1. ADS Operator ______
2. Winch Operator ______
3. Stand-By Swimmer ready ______
4. Stand-By Boat and Crew ready ______
5. Location, Tracking Equipment available - State Equipment to be used:

______

______

6. Emergency Recovery Method to be used: ______

______

______

7. ADS Operator has been adequately briefed, is suitably equipped and understands his tasks. ______
8. A fitness to Dive Certificate has been signed by the ADS Technician in charge. ______
9. A fitness to Dive Certificate has been signed by the ADS Operator. ______
10. All Back-Up Personnel have been briefed regarding their duties and are in position:

    Communications ______
    Winch ______
    Deck Handling Crew ______
    Swimmer ______
    Recovery Boat Crew ______
    Personnel to operate emergency recovery method ______

11. Area safe and free from hazards unless known (in which case state details):

______

______

12. Clearance obtained (from the Master of the Vessel or from the Manager of the Rig) to commence the Diving Operation. ______

I hereby certify that the items on this check list have been properly completed and permission has therefore been granted for the Dive to take place.

Signature ______ ______

Time ______

Date ______

D.H.B. CONSTRUCTION LTD

L O G

LOCATION____

DIVE No.____

PURPOSE OF DIVE____________________________________

DIVE CERTIFICATE No.____________ TIME____________ DATE____________

CONTROLLER________________________ OPERATOR____________________

* * * * * * *

HARD LINE COMMUNICATION CHECK____________________________

DOME CLOSED____

IN WATER____

WATER LEAKAGE CHECK__________________________________

THROUGH WATER COMMUNICATIONS CHECK________________________

ON BOTTOM____

PO_2______ HPO_2______ LPO_2______ C.P.______ TEMP______ DEPTH______

D.H.B. CONSTRUCTION LTD

A.D.S. FITNESS TO DIVE CERTIFICATES

MAINTENANCE SECTION A.D.S. No.____________

A.D.S.			TICK
1.	All 'O' ring seals in position and limbs correctly tightened		______
2.	All joints correct and free to move		______
3.	Required manipulators fitted and checked	Port	______
		Starboard	______
4.	CO_2 scrubber charged and correctly fitted	Port	______
		Starboard	______
5.	O_2 cylinders charged and valve open	Port HPO_2	______
		Starb HPO_2	______
		Port LPO_2	______
		Starb LPO_2	______
6.	O_2 controllers operating satisfactorily	Port	______
		Starboard	______
7.	Front BallAST WT fitted	lb. wt.	______
	Release mechanism free		______
8.	Rear Ballast WT fitted	lb. wt.	______
	Release mechanism free		______
9.	Back pack fitted and secure		______
10.	Flashing beacon fitted and secure		______
11.	Rear battery pack charged and fitted/plug greased		______
12.	Communications/lifting cable correctly fitted		______
13.	Cable Jettison system satisfactory		______
14.	PO_2 monitor functioning satisfactory		______
	Un-used battery in B.		______
15.	Hatch and operating system satisfactory		______
16.	Suit interior and ports clean and dry		______
17.	CO_2 change over valve clean and dry & operable		______
18.	Through water communication system checked		______

Date______________, Time______________, Signature____________________

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A.D.S. FITNESS TO DIVE CERTIFICATE (cont'd)

Surface Equipment

19. Winch power pack fuel tank full oil ____________

engine oil checked ____________

ready to run ____________

20. Visual check of winch cables and terminations ADS ______ ______

ADS ______ ______

21. Visual check of winch drums, motors, hoses valves ADS ______ ______

ADS ______ ______

22. Power available to lights and connected to winch drum ____________

voltage ____________

23. Lamp heads checked

Voltage of lamp(s) ____________

Wattage of lamp(s) ____________

24. Surface communications satisfactory ____________

certifying that all items on this check list have been properly completed

Signature ____________

Time ____________

Date ____________

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Fitness to Dive Certificate - ADS Operator

ADS No. ________ ADS TYPE ________

1. Purpose of Dive and Anticipated Duration

____

____

____

2.	O_2 Bottle Valves open.	Port	________
		Starboard	________
3.	Back Pack Cover fitted and secure.		________
4.	Emergency Lifting Point satisfactory.		________
5.	Face Mask, Valves, Tubes, Fittings, Couplings	Inhale	________
	correctly fitted and operating satisfactorily	Exhale	________
6.	ADS Clear to enter, clean and dry.		________
7.	Beckman PO_2 Monitor on (Battery A) stabilized at 160 Mm Hg		________
8.	Starboard Life Support System checked satisfactorily	HPO_2	________
	and Oxygen Shut-off valve in Suit closed	LPO_2	________
9.	Port Life Support System checked satisfactorily	HPO_2	________
	and System left in operation.	LPO_2	________
10.	Combined Communication and Lifting Cable Jettison Systems free to be operated.		________
11.	Communications Systems satisfactory.	Hard Line	________
		Thro'-Water (Battery Test)	________
12.	Thro'-Water Transducer deployed.		________
13.	Ballast Jettison Systems free to be operated.	Front	________
		Rear	________
14.	Flashing Beacon activated.		________
15.	Cabin Pressure Gauge adjusted to read zero.		________
16.	Hatch clean and ready to close and Operator ready to dive.		________

I hereby certify that I have seen the Fitness to Dive Certificate in respect of this ADS which has been signed by the ADS Technician in charge. I also certify that all items on this check list have been properly completed.

Signature ________

Time ________

Date ________

CONSENT TO VOLUNTARILY PARTICIPATE IN A RESEARCH DEVELOPMENT TEST OR EVALUATION (RDT&E) PROCEDURE

1. I hereby volunteer to participate as a subject in a research program being conducted under the work unit title "Physiological Performance and Human Engineering Evaluation of One-Atmosphere Diving Systems."

2. I understand that the following procedures will be employed in this study: I will be performing specially developed underwater performance tasks, related to tasks a Navy diver would ordinarily be performing, such as placing and securing patches on equipment to secure them as water tight, connecting bolts to equipment to assemble different pieces of apparatus, and torqueing down bolts which will be accomplished while I am operating a 1 ATA diving system from inside. I understand that in addition to work measurements and procedures, physiological measures will be taken in a number of different situations. These conditions are: (a) electrodes for heart rates (electrocardiograms), rectal temperature probes to obtain body temperature; respiration rate to measure breathing. These are standard physiological measures accomplished under proper supervision. The depths will average 20 feet and, at no time in this experimental phase be deeper than 100 feet.

3. The work will be done using a tested one atmosphere diving system in protected tanks and shallow conditions under approved Navy diving procedures.

4. I understand that the information derived from this study will ultimately provide a basis for improved development of underwater task performance that will benefit dive planning, dive efficiency and safety.

5. I understand that I am free at any time to ask any inquiries concerning the procedures employed in this study and the investigators will freely respond to these inquiries.

6. I understand that I can withdraw from the study or freely omit procedures without reproach and without jeopardizing my status at any time that I wish.

7. I have read both this consent form and the form approved for this study by the NMRI Committee for the Protection of Human Subjects.

DATE:________________ SIGNED:______________________

(Typed name, rate, rank or grade)

WITNESSED:________________ DATE OF BIRTH:________________

APPROVED:______________________

SYSTEMS READINGS

		PORT		STARBOARD				
TIME	PO_2	HPO_2	LPO_2	HPO_2	LPO_2	CP	TEMP	DEPTH

		PORT		STARBOARD				
TIME	PO_2	HPO_2	LPO_2	HPO_2	LPO_2	CP	TEMP	DEPTH

		PORT		STARBOARD				
TIME	PO_2	HPO_2	LPO_2	HPO_2	LPO_2	CP	TEMP	DEPTH

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DIVE LOG

Job No.	Client	Date
Vessel Structure	Location	Depth
Wave Height	Wind Speed	Water Temperature
A.D.S. Type	A.D.S. No.	Standby System
Operator	Surface Controller	Standby Operator
Hatch Close	Hatch Open	Dive Duration

Purpose of Dive:-

Job Remarks/Sketches:

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WEEKLY REPORT LOG

Job No.	Client	Week Ending
Vessel Structure	Location	Depth

Date	Activity

NAVAL SEA SYSTEMS COMMAND
SYSTEM CERTIFICATION SURVEY CARD
ADS JIM-4

SYSTEM ______________________ REVIEWED BY ______________________

PSOB ITEM ______________________ REVIEWED WITH ______________________

DATE ______________________

____ CATEGORY IA - Must be accomplished prior to manned use

____ CATEGORY IB - Must be accomplished prior to granting system certification

____ CATEGORY II - Desirable

FINDING:

DISCUSSION:

RECOMMENDATIONS:

CORRECTIVE ACTION TAKEN (SUMMARIZE):

______________________ NAME ______ DATE

SURVEY CARD NO.______

USN Operations and Maintenance Logs for JIM Dives

An operation and maintenance log shall be kept by the diving Supervisor for all JIM dives and maintenance procedures, including routine maintenance.

A. The Dive log shall consist of:

Dive Officer: ____________
Dive Supervisor: ____________
Diver: ____________
Tenders: ____________
Phones: ____________
Location: ____________ Depth: ________
Surface Platform: ____________ Water Temp: ________
Visability: ________ Bottom: ________

Time Door Closed: ________
In Water: ________
On surface: ________
Time Door Opened: ________
TTD: ________

Tasks and Performance Comments:

Suit Problems experienced:

Comments and Operator Debriefing:

B. Maintenance logs shall consist of:

Reason: ____________
Technician: ____________
Assisting Personnel: ____________
Description of Maintenance or Repairs Accomplished:

Description of any items or substances added or removed from the suit:

Life support Systems status after maintenance

Dive Supervisor for next dive: (initials)

"JIM" Evaluation

Dive Log Sheet

Date: ______________

Dive Officer: ____________________

Dive Supervisor: ____________________

Diver: ____________________

Tenders: __________________

Phones: _________________

Location: ____________________

Depth: __________

Surface Platform: ___________________

Water Temp: __________

Visability: _____________

Bottom: __________

Time Door Closed: __________

In Water: __________

On surface: __________

Time Door Opened: __________

TTD: ___________

Tasks and Performance Comments:

Suit Problems experienced:

Comments and Operator Debriefing:

"JIM" Evaluation

Maintenance Log Sheet

Date: ____________
Time: ____________

Reason: ____

Technician: __________________________

Assisting Personnel: ___________________________________

Description of Maintenance or Repairs Accomplished:

Description of any items or substances added or removed from the suit:

Life support Systems status after maintenance:

Dive Supervisor for next dive:

POST DIVE QUESTIONNAIRE

ONE ATM SYSTEM "JIM"

NAME ____________________

DATE ____________________

AGE __________

YEARS EXPERIENCE IN DIVING ______

RATE __________

DIVE SITE ________________

HOURS DIVING IN "JIM" ________